# EFFECTS OF VIGILANCE DECREMENT ON THE RECOGNITION OF EMBEDDED FIGURES

Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF ARTS

of Rhodes University

by

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December, 1971

## ACKNOWLEDGEMENTS

The writer wishes to thank the following for their assistance:

Mr. H.W. Page, Senior Lecturer in Psychology at Rhodes University;

Mr E. Parsons, Technical Assistant to Rhodes University Psychology Department;

Prof. D. Z. De Villiers, Prof. of Psychology at Rhodes University;

The Rhodes University Library;

*"The financial assistance of Human Sciences Research Council in connection with the publication of this work, is hereby acknowledged. Opinions expressed in this work or conclusions reached, are those of the author and must in no instance be regarded as a reflection of the opinions and conclusions of the Human Sciences Research Council."*

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# INTRODUCTION

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## INTRODUCTION

Field independence was described by Witkin et al (1962) as the ability to separate an item perceived from its context. Here most experiments have used visually presented material where the subject was shown a simple geometrical figure and then a complex one containing the simple figure as part of it: the subject's task was to find and point out where the simple figure was hidden.

Recent work has suggested that the skills involved in Witkin's tests might be associated with particular cultural backgrounds. This extension of Witkin's theory of field independence by Wober linked visual phenomena with those of a social and maturational nature: the ability to separate visual items from their context was shown to be aligned with the development of a sense of personal identity; the person was considered to be an item set in a context or social field, be it family or society around him: an individual, depending on the way he was socialized as a child, may perceive the world analytically, if he did he was labelled field independent, if not he was field dependent.

In/...

In this way the theory became one of psychological differentiation. Thus, one who was able to see an embedded item was labelled field independent.

Lately field independence has been associated with seeing objects against a complex background in motoring where field dependent people demonstrated difficulty in spotting objects on the road while driving. However, because in motoring target objects appear irregularly at unknown intervals, sometimes infrequently, the motorist has to be constantly watchful and often for protracted time periods. Such a situation can be described as a vigilance task with all the ingredients being present for a decline in performance efficiency over time. Whether such a decline is related to field dependency or not has not been shown.

This study therefore has investigated performance decline over time on an embedded figures test .

In a broader context of motoring and road safety the measures developed in this studv could prove to be useful indices of driver performance.

# CHAPTER 11

# HISTORY, DESCRIPTION, PURPOSE OF THE EMBEDDED FIGURES TEST AND FACTORS AFFECTING PERFORMANCE ON AN EMBEDDED FIGURES TEST.

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## HISTORY, DESCRIPTION, PURPOSE OF THE EMBEDDED FIGURES TEST AND FACTORS AFFECTING PERFORMANCE ON AN EMBEDDED FIGURES TEST

The resurgence of interest in cognitive functioning has resulted in a quick increase in research on field articulation (Long, 1962). Gardner and Long (1960) cited by Long (1962) pointed out that cognitive control principles influenced individual differences in learning and remembering under certain conditions; field articulation is one of these principles and was defined by Gardner and Long as the "capacity to articulate, or differentiate, complex stimulus fields". Gardner and Long found that the articulation of complex external stimulus fields may be accomplished in situations such as Witkin's (1954) Embedded Figures Test (EFT) and Rod and Frame Test by directing the subject's attention to the relevant stimuli in the field while at the same time inhibiting his attention to distracting or irrelevant stimuli (Long, 1962)

Gardner, Holzman, Klein, Linton, and Spence (1959) were cited by Gardner and Long (1961, p. 305) as having

> ...suggested that the commonality linking responses to these [above] superficially different tests was the requirement that S [the subject] attend selectivily to relevant vs irrelevant cues.

Witkin (1950) pointed to the conceptual and perceptual approaches to solving problems in the EFT; the latter approach resembled adherence to the pattern of the complex figure itself which was accompanied by poor scoring rather than forming hypotheses as in the former cognitive approach which was associated with high scoring. Baggeley (1955) had arrived at a similar conclusion to Gardner et al's (1959) in order to explain the process involved in Thurstone's Concealed Figures Test (1944) where the subject was required to discover a familiar object or figure hidden in a complex scene (Witkin, Dyk, Faterson, Goodenough, and Karp, 1962). He said that the capacity to find these hidden figures involved "concentration on one aspect of a complex stimulus situation." The concept of selective attention has, according to Long (1962), been employed to account for the observed individual consistencies in coping with the interference or distraction present in the various tasks used. Witkin, Dyk, Faterson, Goodenough and Karp (1962) suggested that the EFT probably involved an "attention concentration factor" and that a high EFT time might in fact reflect an attention difficulty rather than the preferred mode of field approach.

Embedded figures tests have been largely based on Gottschaldt's (1926) study of the role of past experience in perception (Witkin, Dyk, Faterson, Goodenough and Karp, 1962). The purpose of his study was to demonstrate the importance of contextual factors in perception (Witkin, 1950), that is, the subject had to locate the simple figure previously seen within a complex figure; the simple figure was incorporated within the larger complex figure such that it was perceptually obscured (Jackson, 1956). The structure of the complex figure determined how easy or difficult it was to locate the simple figure (Witkin, 1950). Gottschaldt's (1926) finding, later confirmed by Witkin (1950), showed that patterns of a given structure were more effective than patterns of another in concealing the figures they contained. However, the structure of the field alone could not fully explain this as personality factors were important, said Witkin *(ibid)*, who cited self - consistency and field dependency and independency as examples.

According to Jackson, Messick, and Myers (1964) field independence was defined by performance on 3 tasks defined as

> ...individually - administered laboratory spatial orientation procedures, each requiring S [subject] to adjust an object (in certain instances his own body) to the upright in the face of conflicting information from visual and proprioceptive modalities. (Jackson, Messick, and Myers, 1964, p. 178.)

According/...

According to these writers it was only later discovered that performance on a printed individually administered embedded figures test, composed of Gottschaldt's (1926) figures with colours added to raise the difficulty, correlated highly enough with measures of laboratory orientation to indicate using it as a measure of field independence (Witkin, 1950). An extensive study of perception - personality relations by Witkin, Lewis, Herzman, Machover, Meissner, and Wapner (1954) provided further proof that the EFT correlated significantly with measures of orientation to the upright, as well as with a large number of personality traits. The EFT requires the subject to separate an item from the field within which it is incorporated but, unlike orientation procedures, it involves neither the body position nor orientation towards the upright and can be a perceptual or tactile task (Witkin, Dyk, Faterson, Goodenough, and Karp, 1962). Jackson (1956), in describing a shortened individual form of Witkin's EFT, suggested that Witkin's tests would most likely be used in the future to test for field-dependence, as only a small investment in apparatus and materials was required as compared with the orientation procedures. Jackson, Messick and Myers (1964) stated that this in fact had happened. Witkin, Dyk, Faterson, Goodenough, and Karp (1962) considered the EFT as one of a standard battery to test field dependence central to which dimension was the ability to overcome an embedding context.

Hence the relationship between field dependency and embedded figures tests.

There are a number of different embedded figures tests which use different methods and techniques. One type presented key figures one at a time, another placed several before the subject at once, in the third type the subject was required to search for the key figure in every item. The key figure may be kept before the subject during the search or he might have to remember the key figure while examining the complex figure. (Cronbach, 1961). Similar tests to Witkin's EFT are the Hidden Figures test which is an adaptation of Thurstone's Gottschaldt test, and the Hidden-Digits test (Witkin, Dyk, Faterson, Goodenough, and Karp, 1962). These writers also cited the Children's Embedded Figures test (CHEF) which was developed to provide an EFT-type situation suitable for use on young children: it was attempted to make this test intrinsically interesting to children, to avoid sustained attention as a necessary requirement, to reduce the frustration following failure, and to ensure that the task would be clearly understood.

In Witkin's (1950) individual EFT the task of the subject was to find a particular simple figure within a larger and more complex figure or embedding context consisting of more complicated geometric designs and distracting lines (Messick and Fitzby, 1963).

The simple figure was hidden in the larger complex figure by being incorporated into its patterns. That is, the outline of the simple figure may form the boundaries of several subpatterns in the complex figure. (Witkin, Dyk, Faterson, Goodenough, and Karp, 1962). The figures in this test were selected from the figures developed by Gottschaldt (1926) to study the role of past-experience in perception. Preliminary experiments had shown that it was impossible to obtain a large enough number of difficult figures from Gottschaldt's black and white outline complex figures or to make up such figures by using his principles of patterning. It thus became necessary to develop added methods of obscuring the simple figures and it was found that colouring the complex figures, which tended to reinforce a given pattern and its subpatterns, was effective (Witkin, 1950).

The standard Witkin EFT administered to both men and women uses a series of 8 simple figures accompanied by 24 complex figures; within each of these complex figures a simple figure must be located (Witkin, Dyk, Faterson, Goodenough, and Karp, 1962.) Fig. 1 shows Witkin's illustrations of these where

> The simple figures are designated by a letter; the complex figures are designated by a letter and a number, the letter corresponding to that of the simple figure which it contains. Figures P and P-1 are the practice figures.
>
> The specific colours used in each complex figure are represented by numbers; and wherever necessary the

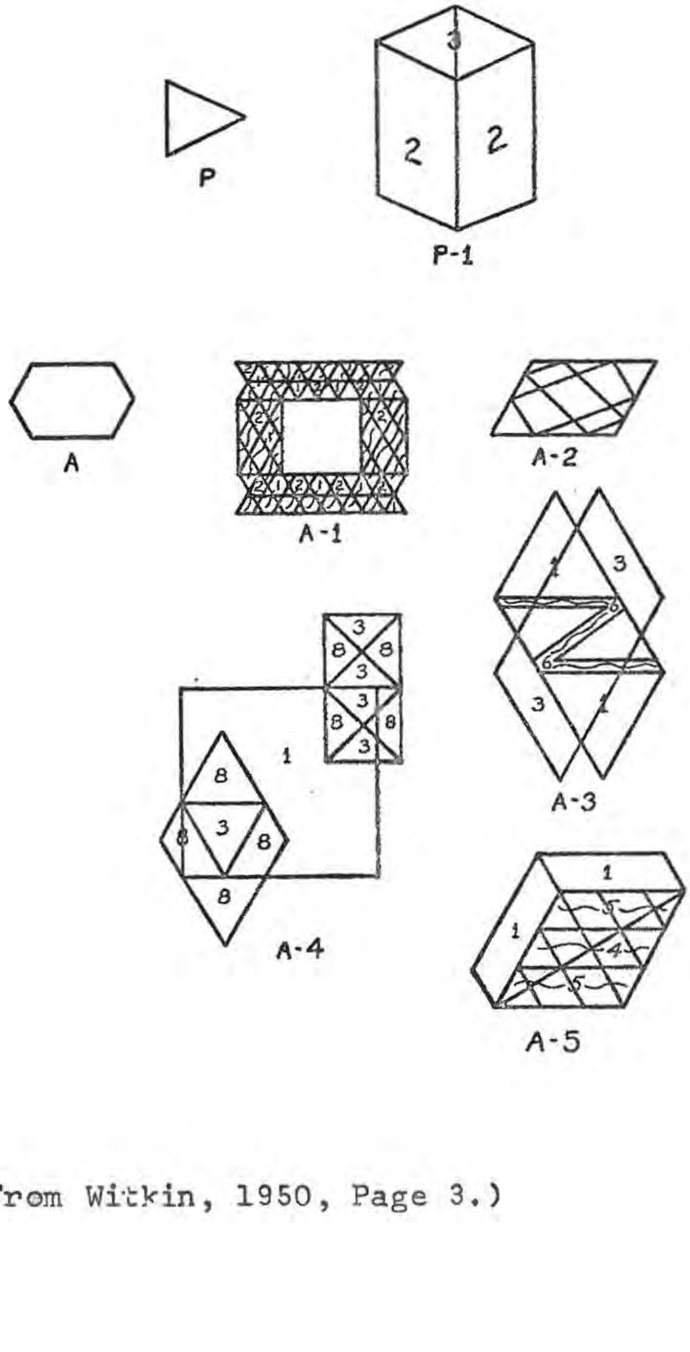
> area covered by a given color is indicated by wavy lines radiating from the number. Figure A-2 remained uncoloured. The colours to which the numbers refer are as follows: 1 - red, 2 - blue, 3 - orange, 4 - yellow, 5 - brown, 6 - dark green, 7 - light green, 8 - black. (Witkin, 1950, p.3.)

The figures were graded in difficulty and there was a large enough variety so that one figure was not encountered too many times thereby reducing the effect of practice. Each subject was given a practice trial. The subject was required to work quickly and the task was therefore a timed one (Witkin, 1950). The procedure required that a randomly selected complex pattern be presented as the first figure and for 15-seconds followed by a presentation of the simple figure for 10-seconds when the complex figure was removed. The simple figure was then replaced by the same complex pattern and the subject's task was to locate that particular figure within it. A maximum of 5-minutes was allowed per trial to locate the simple figure. The subject was permitted to re-examine the simple figure but was discouraged from taking more than 10-seconds for each re-examination. (Witkin, Dyk, Faterson, Goodenough, and Karp, 1962).

The subject's score was the time taken to locate the simple figure excluding time of re-examination of the simple figure. Failure to locate the figure was scored as 5 - minutes (F).

The simple figure requiring location was never the same on any 2 successive trials and the complex and simple

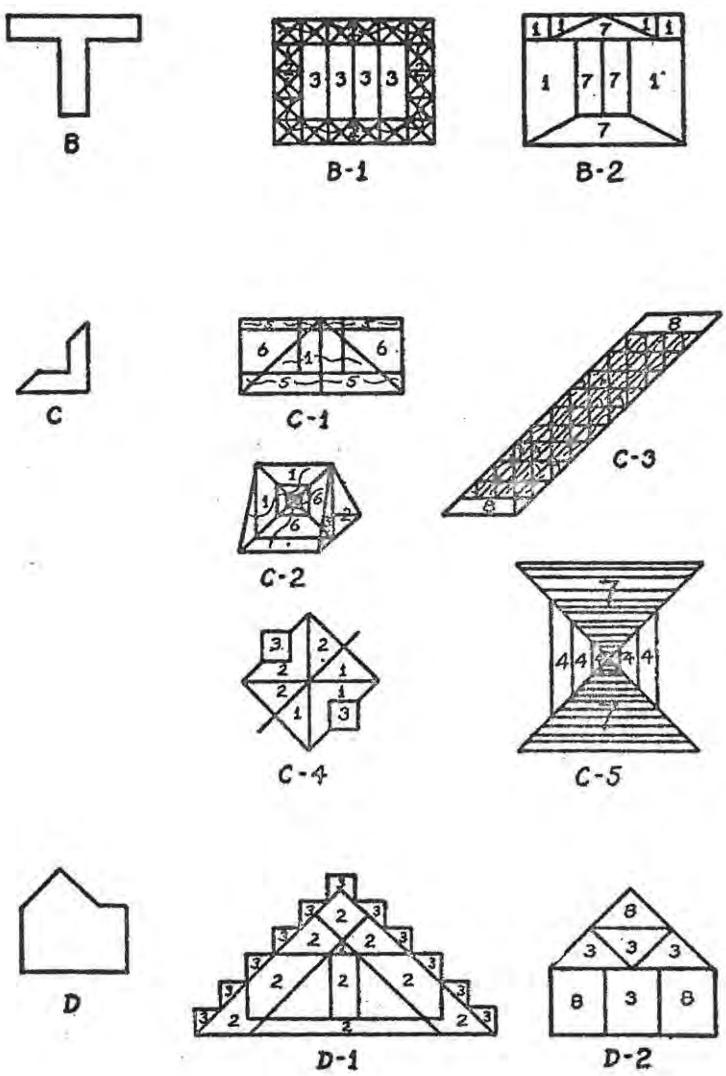
FIGURE 1 - WITKIN'S EMBEDDED FIGURES TEST




(From Witkin, 1950, Page 3.)

Cont...

FIGURE 1 - WITKIN'S EMBEDDED FIGURES TEST

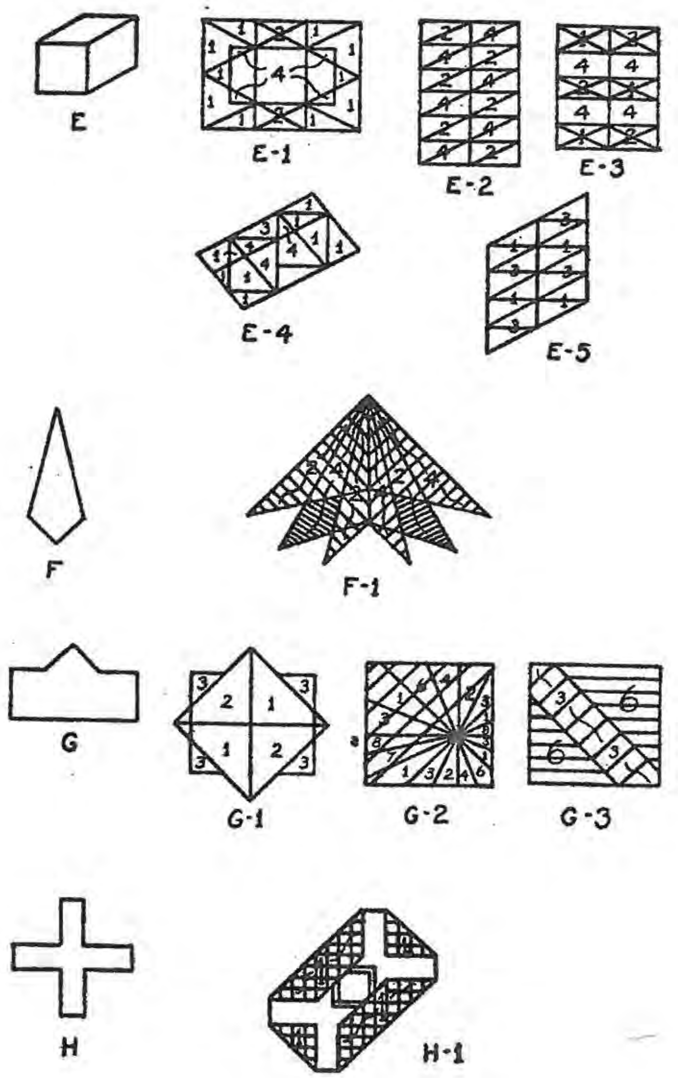



(From Witkin, 1950, page 4)



Cont...

FIGURE 1 - WITKIN'S EMBEDDED FIGURES TEST




(From Witkin, 1950, page 5. )

figures were never presented together. The presentation of the complex figure before the simple figure and presenting a different figure on each trial was intended by Witkin to impress the total complex pattern upon the subject and to discourage searching for a specific simple figure. In a preliminary study where the simple figure was presented first, Witkin had found that the subjects concentrated their attention on a portion of each complex figure, disregarding the over-all pattern of each. This attitude was helped by the simple figure usually being located in part or in whole, near the centre of the complex figure. The repeated search for the same simple figure on successive trials also induced a specific "set" towards that figure. According to Witkin the procedure used here increased attention to the overall complex pattern and so served to increase the task's difficulty.

The details of the procedure (Witkin, 1950) which have been adapted for the present study are as follows. At the beginning of the EFT Witkin gave the subject the following instructions:

> I am going to show you a series of coloured designs. Each time I show you one of these designs, I want you to describe the over-all pattern that you see in it. After you examine each design, I will show you a simpler figure, which is contained in that larger design. You will then be given the larger design again, and your job will be to locate the smaller figure in it. Let us go through one to show you how it is done. (Witkin, 1950, p. 6.)

The subject was then shown the practice complex figure (P-1) for 15-seconds, it was removed and the practice simple figure (P) was then shown for 10-seconds. On its removal the complex figure was again presented with instructions to find the simple figure in it. The subject was timed and his score was the time taken to find the simple figure. When the subject reported finding the figure, he had to trace it for the experimentor (E) who had to be sure it was the correct one.

After this practice trial, the subject was given further instructions:

> This is how you will proceed on all trials. I would like to add that in every case the smaller figure will be present in the larger design. It will always be in the upright position. There may be several of the smaller figures in the same large design, but you are to look only for the one in the upright position. Work as quickly as you possibly can, since I will be timing you; but be sure that the figure you find is exactly the same as the original figure both in size and in proportions. As soon as you have found the figure, tell me at once. If you ever forget what the small figure looks like, you may ask to see it again. Are there any questions? (Witkin, 1950, p. 7.)

This procedure was used on the 24 test trials. Subjects, although not allowed to, often attempted tracing movements with their hands and had to be stopped (Witkin, 1950). Witkin remarked further that subjects often experienced "blocking" of the simple figure by the conflicting complex pattern and some subjects required more than $1\frac{1}{2}$-hours to extract the simple figures from the 24 complex figures.

The score for each item was the time needed to locate and trace the simple figure in the complex pattern (Jackson, Messick, and Myers, 1964). If not correct, the subject continued searching till correct and the time employed in tracing the incorrect figure was included in the final score while the time taken in referring back to the simple figure was excluded (Witkin, 1950). The subject's score was the mean amount of time required to locate and trace all the simple figures within the appropriate complex ones: this provided a measure of the extent the subject's perception was influenced by the context in which the item was embedded; the raw score was converted to a standard score with positive standard scores "reflecting relatively field-dependent and negative standard scores relatively field-independent performance" (Witkin, Dyk, Faterson, Goodenough, and Karp, 1962). [See Appendix 1 for detailed results of Witkin's EFT as quoted from Witkin (1950).]

Jackson (1956) conducted an item anylysis of the EFT and suggested using a 12 instead of 24-item-test with a 3-minute time limit instead of a 5-minute one. He reported high reliability correlations between the standard and the full length EFT for several groups of Ss. Witkin, Dyk, Faterson, Goodenough, and Karp (1962) have reviewed later studies of reliability of the short test as compared to the longer and have confirmed high reliability.

Variables influencing performance on embedded figures tests are motivation, brain damage, genetic and environmental factors, alcohol, age, inter and intra - sex differences, and practice.

Motivation is an important variable of performance in the EFT where the subject is told that an ability is being measured and this provides him with a "culturally defined ideal of behaviour"; the subject now understands that a high score is desireable and he understands how such a score can be attained (Cronbach, 1961). It must be remembered that motivation is not standard for every individual and a performance test of personality like the EFT must attempt to keep motivation standard for the subjects to the same degree as it is kept standard for tests of mental ability (Cronbach, 1961).

Barrett and Thornton (1968) found that brain damage, genetic, and enviromental factors could decrease the ability to pull an embedded item from its context. He had subjected 20 drivers to a controlled emergency situation in an unprogrammed automobile simulator where a pedestrian (a dummy) emerged from a shed into the path of the vehicle. Karp, Silberman and Winters (1969) found field dependence and related cognitive abilities not to differ with socio-economic status when they administered 6 subtests of the Wechsler Intelligence Scale for Children (3 verbal and 3 performance tests) accompanied by a measure of sophistication -of-body concept to middle and lower class boys; 2 adult male groups (middle and lower class) were given the EFT.

Witkin, Dyk, Faterson, Goodenough and Karp (1962) and Barrett and Thornton (1968) found that with alcohol ingestion the performance on an embedded figures test was impaired. Consequently, Witkin et al suggested that while under the influence of alcohol a driver would experience greater difficulty in extracting an emerging vehicle, pedestrian, and the like from a complex field.

It has been reported (Basowitz and Kerchin, 1957; Crook, Alexander, Anderson, Coules, Hanson and Jeffries, 1958) that senescents performed more poorly than young adults on versions of the Gottschaldt (1926) task: the question could be asked whether this poorer performance was modality specific or whether it perhaps involved a generalized difficulty in ignoring extraneous perceptual information (Axelrod and Cohen, 1961). Axelrod and Cohen compared the performance of young adults and senescent adults on visual and tactile hidden figures tests; the elderly group performed significantly poorer on both tasks. Performance on an embedded figures test is thus influenced by age which also influences driving ability. There should consequently be a relation between field dependency, age, and driving ability. This has been demonstrated by the following results. Witkin (1962) found that field-independent persons responded better to driving situations as they tended to think more analytically and critically while field-dependent persons tended to become confused, disorganized and inadequate (Barrett and Thornton, 1968):

Goldstein/...

Goldstein (1961) had shown that drivers younger than 25 years of age and drivers older than 65 years of age have a disproportionately high accident rate (Barrett and Thornton, 1968) and it has also been shown, said Barrett and Thornton that perceptual style could be a function of age: Witkin et al (1962) found that field independence increased with age among individuals with an asymptote around 21 years of age and said that children had been found to be more perceptual, in contrast to conceptual, than adults in their approach and that on the EFT they have extreme difficulty. Because drivers of 16 to 21 years of age are fairly field dependent might be one reason for their higher accident rate was a suggestion by Barrett and Thornton (1968). They said that the younger group did have faster reaction times, but that this was cancelled out to a certain extent by the real-world situation involving a complex perceptual element requiring the intruding object to be recognised first before any action could be taken. Similarly, Barrett and Thornton also cited Schwartz and Karp (1967) who had found older individuals to be field dependent.

Witkin et al (1962) found women to be more influenced by visual structure and to require more time than men in the extraction of an item from the visual structure of which it is a part; they found the range of scores for women to be greater than men who remained self-consistent in their times scores throughout the trials on the EFT while women showed slightly lower correlations than men indicating greater variability from trial to trial.

Women/...

Women as a group had thus been shown to be more field dependent than men which led to the prediction that they would be less effective than men when presented with an emergency situation in driving: Uhr (1959) had found women to be more likely than men to cut across the path of a motor scooter from a stop street due possibly to their inability to perceptually extract the small scooter from the background as quickly as men (Barrett and Thornton, 1968). Bieri, Bradburn, and Galinsky (1958), like Witkin et al (1962), found males to be superior on tests of spatial relations: in men, preference for complexity in drawings on the Art Scale related significantly to better EFT performance; in women the tendency to perceive others in a more external and field dependent way was related significantly to poorer EFT performance, the same was found for men when only extreme scores on the EFT were used. They concluded that the observed sex differences in EFT performance stemmed from men's tendency to combine more effectively mathematical aptitude and a conceptual approach to stimuli. Similarly, men have been found to be generally more adept than women on field articulation criterion tests (Witkin, et al,1954 ). Goldstein and Chance (1965), using an extended series of 68 embedded figures to test men and women, found that the initial significant sex-related mean difference in reaction times was reduced to practically zero by the final trials. In contrast to the large amount of data indicating a faster and more accurate EFT performance among males, Jackson, Messick and Meyers (1964) did not find significant sex differences in their sample for any of the embedded figure tests, not even for the Witkin items individually administered. This finding may have been attributable to the more stringent selection standards maintained for females as compared with male applicants at the university from which they drew their sample given the known positive correlations between intellectual ability and embedded figures test performance (Thurstone, 1944; Witkin, Lewis, Hertzman, Machover, Meissner, and Wapner, 1954; Jackson and Messick, 1960; Goodenough and Karp, 1961; Witkin, Dyk, Faterson, Goodenough and Karp, 1962; Messick and Fritzby, 1963) which they used as their selection criteria. By way of summary, the degree of ease in perceiving a part within a larger visual structure was a "persistent characteristic of each individual and ... people differ markedly both inter and intra sexes" with women showing a wider range than men (Witkin, 1950); there was agreement within and between sexes regarding improvement of performance with practice (Goldstein and Chance, 1965).

Driving a car is a vigilance task in that the driver must constantly be alert for perceptual cues and attend to those perceived; he must also adjust his operation ofthe vehicle accordingly. Visual signals arriving are from an embedding context and the ability to perceive embedded figures has been shown to influence driving ability, thus the relation in the present discussion between embedded figures, vigilance, and driving a vehicle.

What/...

What must thus be investigated is whether performance in embedded figures contexts suffers decrement over uninterrupted and extended time periods in a typical vigilance task involving sustained attention. If this decrement is found it could be possible to utilize the results from embedded figures tests applied in vigilance situations as indices to measure and combat the decrement in visual attention efficiency during driving. This study attempted to provide performance data to cover this apparently little charted area with the hypothesis that some decrement in performance efficiency would occur on an embedded figures test applied in a vigilance situation over an extended time period, both for field dependent and independent subjects.

# CHAPTER 111

# VIGILANCE AND THE FACTORS AFFECTING PERFORMANCE

# CHAPTER 111

## VIGILANCE AND THE FACTORS

## AFFECTING PERFORMANCE

Mackworth, N.H. (1950) and others have used the term "vigilance" to describe tasks that required the S's sustained observation and response to a sporadically presented stimulus over extended time periods. This term also concerned the subject's attentiveness according to Frankmann and Adams (1962). Mackworth, N.H. (1956) defined vigilance as

> ...a state of readiness to detect and respond to certain specified small changes, occurring at random time intervals, in the internal environment. It is a process, which, unlike attention, need not necessarily be consciously experienced. (Mackworth, N.H. 1956, p.1375.)

Jerison and Pickett (1963) saw vigilance as

> ... a human factors area... concerned with the fact that man is much less capable as a detector of signals under operational conditions than would be indicated by laboratory measures of his sensory thresholds. (Jerison and Pickett, 1963, p.211.)

The main difficulty in applying laboratory results to field situations, as seen by Jerison and Pickett (1963), seemed

to/...

to be in the inadequate comparability of field and laboratory situations regarding the costs and values of observing and the probability of occurrence of the signals. Human factors specialists have limited the term "vigilance" to tasks requiring the detection of weak and relatively rare signals. Here vigilance is manifested by the probability of detecting signals (Jerison and Pickett, 1963) and where immediate response for a prolonged period is required (Colquhoun, 1957). Perceptual vigilance or attentiveness was, according to Buck (1966), a

> ...hypothetical construct inferred from the observation that monitoring performance deteriorates under prolonged monotonous conditions other factors remaining constant. (Buck, 1966, p. 291.)

Buck went on to say:

> The results of vigilance experiments are normally interpreted on the assumption that the subjects are endeavouring to comply with the instruction to detect every signal and to respond to it as quickly as possible ... (Buck, 1966, p.291.)

Vigilance tasks must not be confused with classical reaction time or tracking tasks. A performance index often used to detect monitoring performance is the time elapsing between the presentation of the signal and the subject's response. This index commonly includes the time taken to search the display, to detect the occurrence of a critical signal, the time involved in evaluating the event, chosing and making the response and, as such, according to

Buck/...

Buck (1966), "... it differs from reaction time as it has been defined and studied in classical reaction time experiments". Because of this

> ...these time intervals are generally longer than those reported for classical reaction time experiments, and some experimenters have preferred to designate them detection latencies. (Buck, 1966, p.291)

Vigilance tasks differ from tracking tasks in that very little or no learning takes place in a vigilance task (Mackworth, J.F., 1964). Mackworth suggested that the decrement found in vigilance tasks also occurred in the more active tasks but as a rule was masked by learning. Adams, Humes and Stenson (1962) summed up by saying:

> Response requirements in a vigilance task are usually simple and high in the subject's response hierarchy. Conceivably little or no learning occurs, and all that is needed is sufficient stimulation after each response to keep performance level high. (Adams, Humes, and Stenson, 1962, p.14)

McGrath (1963) in Buckner and McGrath (1963) described a vigilance task as follows:

> 1. The task will require the observer to perceive and report a change (a "signal") in his operating environment.
>
> 2. The response behaviour of the observer should have no effect upon the probability of signal occurrence.
>
> 3. The signal to be detected may be either a discrete stimulus added to or taken away from the environment or a change in a continuously or intermittently presented stimulus.

4/...

4. Any type of stimulus may be used as a signal provided it is perceivable by the observer when he is alerted or directed to it.

5. The signal to be detected must be specified for the observer.

6. When the signal is a stimulus not requiring an orientation response, the intensity of the signal stimulus should be close to the observer's detection threshold. The greater the intensity of the signal beyond the observer's threshold, the less relevance the task has for the study of vigilance performance.

7. Signals should occur infrequently. As the rate of signal occurrence approaches the maximum responding rate of the subject, the less relevance the task has for the study of vigilance performance.

8. The ratio of nonsignal stimuli to signal stimuli should be high. The closer this ratio is to 1 : 1, the less relevance the task has for the study of vigilance performance.

9. The temporal order of signal occurrence should be irregular. As the temporal order of signal occurrence approaches absolute regularity, the task becomes less relevant to the study of vigilance performance.

10. The task should be prolonged and continuous. The briefer the work period, the less relevance the task has for the study of vigilance performance. (McGrath, 1963 in Buckner and McGrath, 1963, p.231-32.)

Fraser (1953), cited by Mackworth, N.H. (1956), listed the following similar but not as extensive conditions for a vigilance task:

1.Significant/...

1. Significant signals had to be randomly dispersed among neutral signals which were to be disregarded.

2. There had to be stress conditions (load, speed, duration, etc.).

3. There had to be minimal knowledge of results.

Bakan (1963), in Buckner and McGrath (1963), said that a subject

> ... can determine for himself whether to attend or not attend to the relevant display at any time during the vigil; he can determine the intensity or the continuity of attention; he can attend to irrelevant internal stimuli such as his thoughts, day dreams, fantasies, or stomach contractions; or he can go to sleep. (Bakan, 1963, in Buckner and McGrath, 1963, p.88.)

In view of this freedom which a subject has in a vigilance task, as well as the "complex of subjective factors" related to such a task, Bakan was not surprised that wide differences in performance were characteristic findings in any study of vigilance which highlighted the consideration and explanation of the following 2 facts of vigilance behaviour, namely:

1. The overall level of vigilance.

2. The performance decrement occurring usually as a function of the length of time on the watch.

Theories of vigilance can be discussed under the following headings: Habituation Theory, Inhibition Theory, Activation Theory, Filter Theory, Arousal Theory, Expectancy Theory, and Observing Response Theory. The present study however did not demand a choice between theories or a detailed consideration of them.

## FACTORS AFFECTING PERFORMANCE

The following factors have been considered to affect vigilance performance: Signal regularity, frequency and rate, knowledge of results, time on the watch, time of day, temperature, interpolated rest, presence of the experimenter, individual differences, intelligence, sex differences, age, and extraneous sounds. Following this an overview of summaries of all these effects is given in context of the present study on page 72.

### SIGNAL REGULARITY, FREQUENCY, AND RATE

According to Mackworth, N.H. (1956), the regularity with which signals are presented affects performance depending on whether the signals to be detected, or the unwanted signals, are regular. Regularity in the former assists performance and in the latter hinders it. Baker (1959c) found no decrement in performance if the stimulus events searched for were fairly regularly spaced in time. Baker (1963) in Buckner and McGrath (1963), found the effects of interpolated rest or activity other than task activity to be negligible. The effect was more prominent with irregular intervals where temporal expectancies were difficult to build up. Baker (1959b) compared monitoring performance under 3 conditions of inter-signal regularity and found that the most irregular condition (with intervals of 45 to 600-seconds) showed a significant rise in errors during the second half-hour of monitoring. Buck (1966) cited signal "... infrequency and irregularity, as being characterestic of monitoring tasks in which performance deterioration is found".



Smith/...

Smith, Warm and Alliusi (1966) assessed the relative effects of signal regularity and density on vigilance performance with 2 experiments:

Experiment 1 : 3 density levels (6,24 and 96 signals per hour) were factorially combined with 3 levels of variability (coefficients of variation of 0,01, 0,10, and 1 ). Ten subjects were randomly assigned to each of these 9 conditions.

Experiment 2: 5 density levels (6,12,24,48, and 96-seconds per hour) were combined with the same levels of variability as above. Here 13 subjects were assigned to each condition. Each subject monitored a "blinking-lights" display for an hour after each had been instructed to detect and report any alteration of the lights. In both experiments response times to correctly detected signals declined as a linear function of logarithmic rises in signal density.

Baker (1959b) conducted 3 studies. In the first he obtained reaction time to a test signal.This signal followed a sequence of 20 evenly spaced light signals at 10-seconds or 2-minute intervals, regulary, or irregularly spaced about them. The 10-second regular group yielded a reaction time significantly longer for 2 test intervals shorter than the previous intervals; the 10-second irregular condition gave reaction times that were significantly longer only for a short - test interval not given previously. A second study compared monitoring performance under 3 conditions of regularity of inter-signal intervals.

Only/...

Only the most irregular condition with intervals of 45 to 600-seconds gave rise to a significant increase in errors during the second half-hour of monitoring. Earlier, using the same task, Baker (1958) had found no decrement when the intersignal interval ranged from 36 to 96-seconds. Baker's (1959b) range of intervals was the same as the range used by Mackworth, N.H. to generate decrements in detections with a number of different visual and auditory monitoring tasks. The third study compared missed signals where there was no knowledge of results and when they were repeated until detected. Significant decrements in the second half-hour were found only in the no knowledge of results group. From the above Frankmann and Adams (1962) concluded that Baker's results suggested that in vigilance tasks where there was always irregularity of signals occurring at a low average rate, a marked effect of intersignal interval should have been expected.

Smith, Warm, and Alliusi's (1966) results confirmed the above as they found reaction time to decline as the signal rate increased irrespective of which coefficient of signal variability they used. Similarly, McCormack and Prysiazniuk (1961) attempted to determine the effects of degree of regularity of intersignal interval. They found a linear relation between reaction time and task duration for 35 - minute experimental sessions where stimuli appeared from 30,45,60,75, and 90-seconds apart with an average frequency of 1 per minute.

Their/...

Their 22 subjects were required to depress a switch as fast as possible in response to the appearance of a light which differed in degree of regularity from day to day for 3 days. Besides this above linear relation, time was found to decrease with degree of regularity with which the signal light was presented and remained invariant with length of interstimulus interval. This confirmed McCormack's (1958) results and agreed with Frankmann and Adams' (1962) statement above concerning Baker's results. Buck (1966) concluded that a rise in signal irregularity produced increased increment of reaction time: it however appeared that the independent variable's variation must be quite considerable before a significant effect can be detected. Baker had discovered a similar result by obtaining decrement in a 1-hour session using intersignal intervals ranging between 45 a and 600-seconds. This was however not the case for intervals ranging from 60 to 360-seconds apart, and neither for a constant interval of 150-seconds (Baker, 1959b; McGrath, Harabedian and Buckner, 1959).

Jenkins (1958) using a voltmeter - peripheral-light task, discovered that

> ...pointer signal detection rate in creased in the range of 7,5 to 480 signals per hour. Kappauf and Powe (1959) demonstrated the same relation in the range of 8-80 signals per hour and Nicely and Miller (1957) found it in respect to signal rates of 12 and 72 signals per hour applied to two parts of the same display. (Jenkins 1958, p.660.)

According/...

According to Buck (1966)

> Bergum and Lehr (1962) suggested that they [Ellis and Ahr, 1960] failed to obtain an effect because the range of signal rates (6-24 per hour) was too narrow. York (1962) reported a null relation between signal rate and detection rate but did not give details of decrements. (Buck, 1966, p.295.)

Wallis (1951) pointed out that when signal frequency was increased performance was enhanced in terms of probability of detection but the absolute number of signals missed per hour remained approximately the same (Baker, 1959a). Johnston, Howell, and Goldstein (1966) found superior performance under high signal frequency. They varied a signal frequency of 60 and 150 per session between subjects and a density of 4,8,16, and 32 stimuli within subjects over 4 x 100-minute sessions. The subject was required to monitor an 8x8 matrix to detect, locate, and identify additions and deletions of alphanumeric stimuli. The above result was consistent with the findings of Jenkins (1958) who maintained performance by increasing signal rate and so demonstrated a positive relation between detectability and signal rate. He had received qualitative support from Deese (1955) who had suggested that the rate of target presentation affected their detectability with poorer detection at lower rates. Jenkins (1958) suggested that the average rate of signals had a much greater effect on detection level than short range fluctuations. Colquhoun (1961), cited by Taub and Osborne (1966), observed that many of the tasks showing a direct

relation/...

relation between performance and critical signal frequency had utilized tasks where an increase in the number of critical signals was at the same time accompanied by a decline in normal or noncritical signals. He studied the separate effects of both critical and normal signal rates and concluded that detection efficiency was determined by the probability that a stimulus will be a critical signal, i.e., the number of critical signals divided by the total number of stimuli presented. Jerison and Pickett (1963), Jerison, Pickett and Stenson (1965), and Johnston, Howell, and Goldstein (1966) have confirmed Colquhoun's general findings. However, a recent study conducted by Jerison (1965), cited by Taub and Osborne (1966), suggested that the main variable influencing performance was the number of normal signals and not critical signal probability. Also, they suggested that under certain conditions the percentage of detections declined as the number of non-critical signals increased, even where the critical signal probability was equal. McGrath (1963) found signal rate to affect probability ofdetection but not false detections (Buckner and McGrath, 1963). Taub and Osborne (1966) required 72 college subjects to monitor a clock display for 54-minutes and their results suggested that:

1. Both the percentage of correct detections and percentage of stimuli falsely responded to were inversely related to the number of normal signals presented in a session.
2. Neither the number of critical stimuli nor the probability of a stimulus being a critical signal exerted any influence/...

influence on performance. They wondered whether the probabilities detection performance didn't possibly reach an asymptote and was not affected by further changes in rate of probability.

Thus, according to Mackworth, J.F. (1963):

> ...the proportion of signals detected during a vigilance task has been shown to increase as the rate of signal presentation increased (Deese, 1955; Jenkins, 1958.) From this it follows, and has been demonstrated (Garvey, Taylor, and Newlin, 1959; Baker, 1960), that if "artificial" signals indistinguishable from "real" ones are injected into the task, performance on the real signals will improve. Garvey also showed that when the "artificial" signals were distinguishable from the "real" ones they still helped performance on the "real" signals. The present experiments were begun to determine the effect on the detection of infrequent signals by adding extra signals which were clearly distinguishable from the "real" ones. However, it immediately became clear that another factor was more important than change of frequency and the investigation of this factor was pursued. (Mackworth, J.F., 1963, p.82.)

Faulkner's (1962) results were similar to those of Garvey et al, (1959).

Frankmann and Adams (1962) found most major theories of vigilance to predict maximum decrement of vigilance under low signal frequency. Faulkner (1962) confirmed that an increase in signal frequency would alleviate decrement in the form of missed signals or increased response time with time on a vigilance task. He said that experiments had up till then demonstrated that this decrement did not appear in a multi-signal test - e.g. Broadbent (1950) and Jerison (1957).

Faulkner/...

Faulkner suggested that performance did deteriorate on a multiple source task in terms of variability of performance where a rise in a subject's variability of response meant that there occurred an occasional very slow response to a signal and that the frequency of these slow responses would increase with time. He said that the attempts to improve vigilance performance should aim not only to lower the mean response time or frequency of signals missed, but also to prevent the occurrence of relatively long periods where the subject failed to detect a signal if one appeared. Conversely, Gould and Schaffer (1966) found greater decrement of performance with a rise in the number of channels monitored (8, 12, 16, or 24) and with an accompanying rise in signal rate (18, 16, or 24). They found an increase in the rate of display change (10, 5, and 2,5 seconds) affected performance most followed by the increase in the number of channels monitored.

Mackworth, J.F. and Taylor (1963) found probability of detection not to be related to signal regularity, irregularity or to signal rate (17 - 240 per hour) and that an increased number of signals did not improve performance by increasing arousal. Warm, Loeb, and Alliusi (1970) found that a stable rate of nearly 100% detection was neared at signal durations of 4 and 8 - seconds independently of signal rates. However, Hardesty, Trumbo and Bevan (1963) said:

Vigilance/...

> Vigilance data typically show that the rate of presentation of the critical signals influences both the over-all rate of signal detection (Jenkins, 1958; Smith, 1961) and the within-watchdecrement (Deese and Ormond, 1953): as the signal rate is increased, the proportion of signals detected also tends to increase, and the within-watch decrement tends to be less pronounced. (Hardesty, Trumbo and Bevan, 1963, p. 629)

With a decrease in signal rate Schroeder and Holland (1968) found a decrease in the percentage of signals detected and a decrease in eye movements. Blair and Kaufman (1959) reported that the rate of observing responses did not follow a variation in signal rate, although a measure of time to report signals did do so (Buckner and McGrath, 1963). Frankmann and Adams (1962) found the observing rate to be higher with a higher signal rate. Jenkins (1958) found a greater performance decrement with lower signal rates: the slower the signal rate and the longer the time on the watch, the greater is the tendency to fixate a signal without reporting it (Schroeder and Holland, 1968). Pope (1962) found better performance with high signal rates in both visual and auditory tasks. Frankmann and Adams (1962) cited Jerison and Wallis (1957) and McCormack (1958) as finding interval size to have no effect and also Deese and Ormond (1953), Garvey et al (1958), Jenkins (1958), and Kappauf and Powe (1959) as finding better performance with higher signal rates. Chinnand Alliusi (1964) said that the presentation rate of "critical signals" influenced the "within - watch decrement". (Deese and Ormond, 1953) and the "over-all rate

of/...

of signal detection" (Jenkins, 1958, Smith, 1961). They said that as the signal rate was increased the properties of the signals detected also tended to increase while the within-watch decrement tended to become less pronounced. Similarly, Baker (1963), in Buckner and McGrath (1963), said that the faster the signal rate the more signals would be detected. As an example he cited Woodrow (1951) who had shown shorter intervals to be estimated with greater precision than longer ones. Broadbent also said that better performance and less decrement was found with faster signal rates.

Jenkins (1958) found signal rate to affect false reports at higher rates; the decline in false reports at lower rates was however not proportional to the decrease in the total number of reports at lower rates. The result was an increase in the percentage of false reports with a decrease in signal rate. Jenkins found that when probability based on a high signal rate was high, the subject adopted a liberal criterion for accepting a current stimulus as a signal - a condition which raised the frequency of false reports. A decline in detections during a vigilance task was usually accompanied by a decline in false alarms especially in the first session (McGrath, 1963 in Buckner and McGrath, 1963). Jenkins (1958) found no relation between the percentage of signals detected and the number of false detections. Colquhoun (1961), cited by Buckner and McGrath (1963), found that irrespective of the frequency of the wanted signals he used, where the probability of these

signals/...

signals was low, the percentage detected was lower than when the probability of wanted and unwanted signals was the same.

Lisper (1969), using 4 undergraduates, determined whether "classical" reaction time would increase over time in an ordinary vigilance task. Two signal rates were used, a very high and a low rate. The results showed a rise in reaction time for the high rate and a constant reaction time for the low rate. Predictions from vigilance research e.g. Baker (1963), suggested the opposite and Lisper put his results down as confirmation of the inhibition theory. The discrepancy between this and ordinary vigilance experiments was however considered to have been caused by differences in signal strength (with strong signals here) and as a result of the attention demanded (with low attention required here) as a consequence of the strong signals. Adams, Stenson and Humes (1961) presented 12 signals per hour to subjects and found mean reaction time to increase from about 2 to 3-seconds over a 3-hour session: when 45 signals per hour were presented, the increase was from about 1,25 to 1,75-seconds. These figures suggested that reaction time increment was significantly smaller for the higher signal rate.

Warm, Loeb, and Alliusi (1970) measured the functional relations between watch-keeping performance on the one hand and signal rates, durations, and their interactions on the other using 5 signal durations (5,1,2,4, and 8 - seconds) combined factorially with 5 signal rates (6,12,24, 48, and 96 per hour). They found that reaction time to

correct/...

correct detections increased with time on the watch independently of signal rates and durations. The results indicated that watchkeeping efficiency increased as signal durations were increased to a value between 2 and 4-seconds. This, they said, was in general agreement with an earlier study by Egan, Greenberg and Schulman (1961) which reported that signal detections occurred almost always within 2-seconds in a short term free response task. Warm, Loeb and Alliusi (1970),unlike earlier studies, found signal rates to have little effect in their study. The effects of rate were reflected by only one performance index - namely, detection probability and only with one type of signal and the lowest duration (0,5-seconds). Where detection probability and signal rate had been successfully related, transient signals of 0,5-second duration or less had been used. Also,where reaction time and signal rate had been found to be related, unlimited stimulus durations had been used (Smith, Warm, and Alliusi, 1966). Warm, Loeb, and Alliusi (1970) concluded that the interactions of the above task and signal parameters have important effects on watch - keeping performances. Further, the influence of rate of signals on watchkeeping performance was complicated and a valid psychophysics of watchkeeping would need wider considerations of signal characteristics as well as the matrix of events in which they were embedded.

Broadbent (1953b) distinguished between 2 forms of task which differed in duration of the "watched for event", he called the one paced and the other unpaced. In paced tasks the events were transient and brief and the number of correct detections was used as the performance measure: unpaced tasks were those where the stimuli were not transient but persisted until the subject responded and response latency was the measure of performance (Kappauf and Powe, 1959). In an unpaced condition the subject is able to compensate for momentary lapses and rises in work pauses by raising his rate of work between the pauses; in a paced condition such a pause resultsin loss of opportunity to make a correct detection and there is no chance of compensating by increasing the rate of work at another time. Consequently, according to Broadbent (1953b), little or no decrement was found in an unpaced task as subjects missed fewer signals. Kappauf and Powe (1959) studied an observer-paced task which continued for a long duration in a group situation. The subjects, instructed to work as quickly as possible, worked in test booklets. They searched successively for different numbers for an uninterrupted period of 75-minutes during which time they were uncertain of the time of "appearance" of the number being sought. Detection rate was found to be high and so suggesting a small decrement which in fact did occur significantly. This cautioned one against the generalization which Broadbent advanced, namely, that performance decline is not to be expected with observer paced tasks.

Further/...

Further according to Kappauf and Payne (1959), the result of performance on these above types of tasks have established the following relations very clearly. In paced tasks decline of performance was considerable when low signal rates were used, but became smaller when signal rate was high; the more non-critical signals there were, the greater was the decrement (Jenkins, 1953 cited by Kappauf and Payne, 1959). In unpaced tasks performance decline was much less evident than that expected from data for similar paced conditions: depending on the specific situation and particular method of evaluating the response latency of subjects, decline at unpaced tasks may be negligible or slow to appear (Jenkins, 1953 cited by Kappauf and Payne, 1959). Broadbent (1953b) in fact, as stated above, was inclined to accept the view that decrement does not occur in unpaced tasks.

Hyman (1953) investigated reaction time to visual stimuli as a function of the amount of information carried by the stimulus which was varied by manipulating a) the number of equally probable alternatives from which it could be chosen, b) the proportion of times it could occur relative to the other possible alternatives, and c) the probability of its occurrence as a function of the immediately preceding stimulus. His data showed a linear relation between stimulus uncertainty and reaction time, that it made little difference how a given stimulus uncertainty was reached, whether by restriction of the total number of stimuli, restriction of their probabilities, or by the restriction of

stimuli/...

stimuli sequences. Garner (1962) said the effect of stimulus uncertainty on reaction time had been confirmed by other studies as well.

It has been confirmed that reaction time to several alternative stimuli was affected by their distribution in the set. Crossman (1953), cited by Garner (1962), found, as did Hyman (1953), that frequencies which were unbalanced lowered the average reaction time. Even later Leonard (1958), also cited by Garner (1962), discovered that reaction times were lower with unbalanced than with balanced distributions. Klemmer (1957) also investigated the time uncertainty of the stimulus, his subject knew the form of the stimulus but not when it would appear. Reaction time increased with the amount of time uncertainty.

Bevan and Dukes (1953) have measured reaction time to tachistoscopically presented geometric figures, sometimes telling the subject in advance what the figure would be and other times not. These 2 conditions yielded differences in reaction time. These differences however were reduced to nearly zero when the only response the subject had to make under both conditions was "Recognize". In this last condition there occurred a difference in stimulus conditions but no difference in uncertainty of response. While a slight difference in reaction time due only to stimulus uncertainty was found, the difference was very small (0,42 versus 0,44-second). Bricker (1955) had subjects indentify 8 visual patterns where the number of responses that was

required/...

required varied from 2 to 8. The relation he found between latency of response and response uncertainty had almost exactly the same slope as did Hyman's (1953) relation between stimulus uncertainty and reaction time.

It thus appears, as Hake and Hyman (1953) have demonstrated, that subjects can perceive statistical structuring in a sequence of events and reproduce this structuring in their own response series. They said the subjects did not perceive the probability rules governing the generation of the series of events. Instead, the sequences of events preceding each prediction and providing information about the future behaviour of the series were perceived. Jarvick (1951) and Goodnow (1955) have also demonstrated this probability learning. Thus, temporal uncertainty defined by the signals' temporal regularity can be considered a learned state acquired through experience in the task's temporal intervals. It is inferred from performance as a function of interstimulus interval (Adams and Boulter, 1962). If stable learning of intersignal intervals can occur, vigilance decrement as a function of temporal uncertainty of events cannot be obtained (Boulter and Adams, 1963): "The more regular the temporal interval between signals, the more signal detections" (Baker, 1959b).

Response time is thus linearly related to stimulus uncertainty and so will increase the more uncertain the subject is of the temporal distribution of the critical signal.

Further/...

Further, irregular intervals between signals lead to performance decline as temporal expectancies cannot easily be built up. Reaction time decreases with an increase in signal rate but with irregular signals at low density, that is, with rare signals, performance decline will be marked. A positive relation between detection rate, probability of detection, and signal rate has been found. Maximum decrement of performance can thus be predicted with signals at low frequency or rate and which are irregularly spaced in time. In the present study, therefore, irregular time intervals between critical signals at a low frequency or rate were used to demonstrate decline in performance efficiency over time on the task.

## K N O W L E D G E  O F  R E S U L T S

A means of varying subject motivation and performance was to provide knowledge of results of performance (KR). That is, knowledge of whether a signal had been falsely or correctly reported or missed, and whether it had been responded to more or less rapidly than the previous one.

KR has been shown over and over to improve overall performance and to prevent the emergence of decrement in both active and passive tasks (Mackworth, J.F.,1964a). Jenkins (1958) and Baker (1959c) found KR to minimize performance decrement. KR seems to have a double effect concluded Mackworth, J.F. (1964a): it helped the subject to learn something about the task and secondly, it enhanced motivation. Evidence has been accumulating to support the

first/...

first above effect. Mackworth N.H. (1950) demonstrated that KR prevented performance decrement during a session. He also showed that data for successive sessions were in harmony with the theory that KR aided the subject to recognise the signal better, and that this enhanced discrimination carried over to the next session (Mackworth, N.H., 1964a). Pollack and Knaff (1958) also found a rise in performance following the supplying of KR (Frankmann and Adams, 1962). Baker (1959) suggested that KR allowed the subjects to learn the signals' temporal pattern. He demonstrated that with both KR and a feedback condition there was no significant decrement; with feedback a signal, when missed by a subject, was repeated until detected. Thus there appeared to be the same number of signals in both conditions, but with the feedback condition subjects did not know they had missed a signal.

Weiner (1963),cited by Mackworth, J.F. (1964a), compared KR with partial knowledge of results (PKR) when subjects were told about correct detections and false alarms but not about missed signals. Three groups were run initially, KR ,PKR, and no knowledge of results (NK) groups. Subjects with KR exhibited no decrement and an over-all performance higher than the other groups; the PKR group exhibited a decrement and an over-all performance slightly higher than the NK groups during the first run. In the second run where NK was supplied to all groups the groups

that/...

that had received KR or PKR on the first run had performance that was higher throughout than that of the groups receiving NK in the first trial. Adams and Humes (1963) also found the positive effects of KR to persist in the sessions after its withdrawal. It thus appeared for Weiner's results that even when not informed of missed signals, subjects had learned from PKR. However, false alarms were found to reach a maximum with PKR. This created the possiblity that detection improvement in this condition might have been due to the increased willingness to guess rather than a rise in ability to detect the signal (Mackworth, J.F. 1964a).

Chinn and Alliusi (1964) found that KR of false responses led to a decline in false responses. This was contrary to Weiner's (1962) data above suggesting that PKR may encourage more commissive errors than either zero or full feedback. Chinn and Alliusi found KR of false responses to result in both a significant increase in reaction time to correct detections and a significant decrease in the number of false responses. Mackworth, J.F. (1970) found that feedback following false alarms led to an "exaggeration of the usual increase in caution" which accompanied a decline in false alarms. This could be counteracted, she said, if KR was given about correct detections or missed signals. Chinn and Alliusi (1964) found that KR regarding missed signals produced a significant decrease in

the/...

the total number of false responses. They also found that KR regarding correct detections produced a significant decline in the proportion of missed signals. They said that this KR supplemented the subject's total information input by adding information concerning "errors of omission"

> ...in what may be considered a negatively reinforcing manner. It is difficult to specify exactly what response, or what stimulus - response event, is negatively reinforced, however, since the missed - signal KR is given when an overt response has not been made following the presentation of a critical signal. (Chinn and Alliusi, 1964, p. 910.)

There are thus both positive (information - providing) and negative reinforcing aspects at work and the

> ...occurrence of negative reinforcement following a stimulus - response event will tend to lower the probability of that response's occurring when next the stimulus occurs. (Chinn and Alliusi, 1964, p. 910.)

Not only do knowledge of correct false responses and missed signals decrease decrement, but false knowledge of results (FKR) has been shown to be as effective at improving performance by Davies, McCourt and Soloman (1960) and Loeb and Schmidt (1960) cited by Weidenfeller, Baker and Ware (1962). Weidenfeller et al told subjects that a flashing light indicated a missed signal. This was true of the KR group but not for the FKR group where the light flashed when there had not been a signal. No significant decline in detection occurred during the KR or FKR conditions though a decrement took place with no knowledge of results.

None/...

None of the subjects in the FKR condition reported awareness that FKR was being provided though they did report irritation. Mackworth, J.F. (1970) emphasized that FKR only improved detectability and did not prevent decrement. Another comparison between the effects of KR, FKR and no knowledge of results (NK) on detection in vigilance tasks was made by Mackworth, J.F. (1964a) who compared the effects of KR, FKR, NK on the detection of a brief pause in a clockhand's movement. The best performance and least decrement was found with KR; with FKR the over-all level was intermediate but the decrement rate was the same as for NK; with NK performance was improved following KR, and slightly improved following FKR. Mackworth suggested that subjects learned both the temporal pattern and the characteristics of the signal and this counteracted decrement.

Mackworth, N.H. (1950), cited by McGrath (1963) in Buckner and McGrath (1963), found KR to have no effect on response latency. Adams and Humes (1963) demonstrated that KR reduced the over-all latency as well as its increase during the run but it did not abolish decrement completely. This improved latency was also found to be carried over to later NK runs. McCormack (1959) performed a similar experiment and showed that KR produced less rise in latency during a run than NK. In this experiment the stimulus light (the signal), if missed by the subject, was repeated until detection. Thus the NK condition here was the same as Baker's (1959a) feedback condition, but McCormack found a

consistent/...

consistent decrement when decrement was measured in terms of latency. Similarly, Pollack and Knaff (1958, cited by Frankmann and Adams, 1962),Baker (1959a) and Mackworth, N.H. (1950, cited by Chinn and Alliusi, 1964), have also shown NK to lead to performance decline.

Various experiments have been performed to study the effects of 3 different partial KR schedules on reaction time. One such study by McCormack, Binding and McElheran (1963) used a reaction time experiment under 0%,30%,50%,70%, and 100% KR conditions. The only significant change in reaction time with time on task was observed by the NK group where reaction times became longer with increased task duration. The behaviour of the no knowledge and complete knowledge groups was consistent with previous findings (McCormack, 1962; McCormack, Binding and Chylinski, 1962 ). McCormack and McElheran attempted to determine the critical point which they assumed to be between 0% and 30% KR beyond which the effects of accumulated inhibition was negligible. Five groups of subjects took part in a reaction time experiment under 0%, 10%, 20%, 30%, and 40% KR conditions. Pertinent to the present study was their finding that the only dependable changes in reaction time with time on task were observed for 0%, 10%, and 20% KR groups. Here reaction time became longer with increased task duration. Consistent with earlier studies was the absence of reliable performance change under 30% and 40% conditions.

In/...

In a similar study Johnson and Payne (1966) found performance change to be absent under 50%, 75%, and 100% conditions.

Ware and Baker's (1964) results demonstrated that verbal KR was superior to nonverbal, auditory superior to visual and that KR for misses was superior to KR for detections. Further, when KR was verbally presented, the category of response made no difference to the level of performance; but performance level with knowledge of missed signals given nonverbally, was significantly higher than with knowledge of detected signals. Hardesty, Trumbo, and Bevan (1963) found NK and machine presented knowledge of results to show typical decrement function throughout the session. However, subjects receiving verbal KR from the experimenter exhibited less decrement and significantly higher over-all performance and so confirming the above results. Further, they found observer-presented KR to counteract vigilance decrement whether or not the observer was in the test cubicle. According to Hardesty et al this was attributed by Ammons and Ammons (1956) as due to motivational effects. The failure of machine presented KR to influence performance in Hardesty, Trumbo, and Bevan's (1963) study was contrary to the reports of Baker (1959a) and Weiner (1961). Hardesty et al pointed out that the only obvious difference between this and the earlier 2 studies was that KR took the form of visually presented cues in the earlier studies, and that it could be hypothesised that these cues were similar to the personal KR cues of the above study. They

concluded/...

concluded that the

> ... persistance of the superiority of the observer - presented knowledge of results on subsequent days when all extrinsic knowledge of results had been withdrawn may be taken as further evidence of the motivational nature - in contrast to the informational nature - of this form of reinforcement. Mechanical and observer - presented knowledge of results contained equal amounts of information..., consequently, performance difference must be due to non-informational factors. It is in line with Weiner's (1961) observations that the facilitating effects of knowledge of results persist on a second test day when no knowledge of results is presented. (Hardesty, Trumbo and Bevan, 1963, p.633.)

Adams and Humes (1963) emphasized that not just any verbal stimulation can produce the characteristic KR effects on monitoring a task but the

> ...stimulation must carry with it connotations about response proficiency. McCormack et al (1962) similarly have reported a failure of neutral stimulation to affect vigilance performance and a necessity for KR to be response relevant. (Adams and Humes, 1963, p.152.)

Thus, McCormack, Binding, and McElheran (1963) concluded that performance remained invariant with task duration with complete KR and that this was in accordance with findings of McCormack, Binding and Chylinski (1962). Similarly, Chinn and Alliusi (1964) concluded that on most vigilance tasks a decline in signal detection (which was rapid at first and stabilished after 30-minutes on the watch), may have been prevented by providing the watchkeeper with complete KR- that is, with complete knowledge of correct detections, missed signals, and false responses.

This/...

This absence of decrement was also possibly due to learning something about the task which carried on throughout the run. The temporal aspects of the display and signal characteristics distinguishing it from the systems' general "noise", internal and external to the subject, have been said to be learned here (Mackworth, J.F. 1964a). Baker (1959a) suggested that this complete KR served to establish perception of the true sequential nature of the series, and, according to Mackworth, N.H. (1950) it raised the probability of detection. Mackworth, J.F. (1964a) found that KR increased the ability to differentiate the signal from a given level of noise. KR also increased stimulation, raised arousal level and motivation suggested Hardesty, Trumbo, and Bevan (1963). Similarly, Baker (1959b) said that flagging motivation, and with it performance, could be restored by KR. Further, KR may be seen by the subject as an evaluation of his performance and so may induce a greater need to achieve (Hardesty, Trumbo, and Bevan, 1963).

If there was room for improvement in performance on a vigilance task, performance enhancement would occur when the observer was informed about his performance. The more information he was given, the more he would improve (Weiner, 1962, cited by Jerison and Pickett, 1963). This occurred whether this information was verbal, nonverbal, auditory or visual, with verbal KR being superior to nonverbal, auditory superior to visual, and KR of missed signals being superior to KR of detections (Ware and Baker, 1964).

It/...

It was for these reasons that the present task did not supply the subject with KR. This was done by allowing the subject a choice of one of 2 possible responses or no response which, the former whether correct or incorrect, signalled the next stage of the task.

TIME ON THE WATCH

Mackworth, N.H. (1950) found the critical signals detected over a 2-hour watch to be a decreasing negativity accelerated function of time with the greatest drop occurring during the first half-hour (Frankmann and Adams, 1962 ). Similarly, Mackworth, J.F. (1964b) stated that performance decrement in vigilance threshold determinations and high-speed perceptual **motor** tasks appeared to be a linear function of the square root of time on the task. Also, Chinn and Alliusi (1964) found signal detections to decline as time on the watch increased. In their laboratory and elsewhere (Jerison and Wallis, 1957; Kappauf and Powe, 1959; Baker and Harabedian, 1962; Jerison, 1963) Jerison and Pickett (1963) found decrement to be completed within 15 to 30-minutes after the beginning of a vigil and then to remain at a plateau.

Performance decrement with time on the task has been shown for both paced and self-paced tasks. Saldanha (1957), cited by Mackworth, J.F. (1946), demonstrated an increase in error with time on the task when subjects were required to set a Vernier Guage.

Broadbent/...

Broadbent (1953) and Wilkinson (1961) showed that when a 5-choice reaction time task was self-paced, subjects may maintain their speed at the expense of increasing error with increasing time on the task (Mackworth, J.F. 1964b). To Adams, Humes ,and Stenson (1962) it appeared that with increasing time on the task the subject not only exhibited a general response decrement,but also showed a declining effeciency in scanning with an abondoment of orderly scanning of all display elements. Broadbent (1963,in Buckner and McGrath 1963),found a slow decline in performance for naive subjects expecting a short vigil, an intermediate decline when such subjects expected a long vigil, and a relatively rapid decline for subjects experienced with the task and who anticipated an extended vigil. He concluded that the shape of the decrement function was influenced by the subject's advance information about the job. Bakan (1955) suggested thinking of the decrement over time as being the result of a threshold change, namely, a rise in the threshold for detection over time. Further, Bakan reasoned that if the performance decrement over time on Mackworth's Clock Test was viewed in terms of such a threshold rise, it should be possible to measure decrement by repeatedly measuring the threshold during a prolonged descrimination task. His results showed this. He said that thinking of the decrement as a threshold change not only provided a setting for all decrement data but also led to the assumption, supported in the literature, that if discrimination was made fairly easy

there/...

there should be no or little decrement in response frequency with the course of time.

Regarding the effect of signal rate and time on the watch, the slower the signal rate and the longer the time on the watch, the greater the tendency to fixate a signal without reporting it (Schroeder and Holland, 1968). Jenkins (1958) found that the percentage of all correct responses deteriorated between and within watches with time on the task. This decline was slight for higher rates where false reports accounted for only a small portion of all the reports; but it was fairly large at the lowest rate where more false than correct reports were made. He found the rate of false reports not to decrease during the watch, nor from morning to afternoon. Mackworth, N.H. (1956) found that a decline in the number of successful responses was a function of time spent at the clock test which needed continuous vigilance as the critical signals occurred both irregularly and infrequently. He also found that the slope of performance decline over time was less marked with good than with poor subjects.

Probability of detection has been found to decrease, latency of response to increase, and observing response rate to decrease as a function of time on the watch (McGrath, 1963 cited by Buckner and McGrath, 1963). Holland (1963 in Buckner and McGrath, 1963) cited Fraser (1950) who, using the clock test, showed a greater variance but no average decrement in the number of detections as the watch progressed.

Buck/...

Buck (1966) pointed to the variability of detection rate and reaction time with time on the task under appropriate conditions. This, said Buck, had led to the assumption that these 2 measurers were indices of change of the same psychological variable,but the relation between them was not one of simple covariance with decrement. He said that

> ...under certain conditions, distinguished by high absolute or relative signal intensity and duration, reaction time increases while detection rate remains uniformly high; under other conditions, distinguished by transient signals, reaction time increases while detection rate remains uniformly high; under conditions, distinguished by transient signals reaction time increases as detection rate decreases. (Buck, 1966, p.302.)

McCormack P.D. (1958) and McCormack and Prysiazniuk (1961) found reaction time to increase with time on the task where the inter-stimulus interval varied. McCormack (1960) cited Kennedy and Travis (1947), Mackworth, N.H. (1950) and McCormack (1958) as finding response latencies to increase progressively with task duration where subjects were required to respond to a sporadically presented stimulus. Similarly, McCormack, Binding, and McElheran (1963) found reaction time to increase linearly with time on the task in each of 7 experiments in which subjects were required to respond to a sporadical visual stimulus without any KR of their performance. McCormack and McElheran's (1963) and Mackworth, J.F's (1964a) results agreed with the latter above.

Regarding sex differences in performance over time, Taub and Osborne (1968) found women more able than men to maintain performance over an extended period of time. The finding was in agreement with that of Whittenberg, Ross and Andrews (1956 ).

To summarise and conclude, though women were more able than men to maintain performance over an extended period of time, both sexes showed an increase in latencies of response, their detection thresholds rose, and their percentages of correct detections and observing rates decreased as a function of time on the task where there was temporal uncertainty of the critical signal and no KR. Thus, for the present task, it was hypothesised that with time on the task there would be a similar decline in performance effeciency. Further, subjects were told the length in time on the task as expectation of a long vigil had been shown to enhance decline in performance over time.

TIME OF DAY

Heron (1956) found introverts to perform better in the morning while extraverts performed better in the afternoon. Bakan (1963), in Buckner and McGrath (1963), found more introverts than extraverts to prefer the morning while more extraverts than introverts preferred the afternoon. Jenkins (1958), using a light signal reaction time and pointer signal detection rate with fast and slow signal rates, reported data for a morning and an afternoon session on the

same/...

same day with a break of about 2 hours between sessions. Performance, though improved compared to the end of the morning session, was discovered to become poorer in the afternoon. Rate of false reports however did not decrease during the course of the watch nor from morning to afternoon. Similarly, Wilkinson (1961) reported a morning versus an afternoon session's effect upon overall detection rate while investigating the relationship between intensity, frequency, and number of flashes in determining the critical flicker fusion. The differences he found in respect to decrement were not quite significant and were in the direction opposite to those of Jenkins. Wilkinson however used separate groups while Jenkins did not. Adams and Chiles (1961) found that their subjects who were on work - rest cycles, showed some diurnal variation on their visual task. Best performances (lowest latencies for detections)occurred during the evening and early morning( Jerison and Pickett, 1963).

Best performance seems to occur in the mornings and worst in the afternoons with females being more capable than males over long time periods. This variable may therefore cause those tested in the morning to perform better than those tested in the afternoon,and the less decrement found in the morning may adversely effect the hypothesised results regarding decrement over time on the task. For this reason subjects were tested at one time only. The afternoon was found to be the most convenient for subjects.

## TEMPERATURE

Mackworth, N.H. (1950) found temperature to reduce watchfulness on his clock test when temperature was continuously high. Pepler (1953) and Colquhoun (1957) also found performance in high temperatures to be detremental to performance (Baker, 1959a). There appeared to be an optimal environmental temperature for vigilance: cold may reduce performance throughout a task while heat may increase the rate of decrement (Mackworth, J.F., 1970 ). Baker (1959c) reported that for subjects dressed in shorts, significantly more signals were detected at 79°F than at 70°F and 90°F as found by Mackworth, N.H. (1946, 1950).

In conclusion, performance on a monotonous task may be best at usual environmental temperature. Decrement seems to take place with higher or lower temperatures. For this reason the present task was undertaken at normal ambient room temperature so as not to cause performance differences among subjects.

## INTERPOLATED REST

Jerison and Pickett (1963) cited Mackworth, N.H. (1950) as finding that the interpolation of a telephone message into a single vigil every half-hour led to a "return to initial high performance levels". Baker (1959c) found a rest during a vigilance task to minimise performance decrement while Mackworth, J.F. (1964b) found rest pauses to prevent decrement in both active and passive tasks.

Bevan/...

Bevan, Avant, and Lankford (1967) found interpolated rest to represent a deviation from an otherwise unchanging routine. This suggested that "variability" was a significant property of stimuli for vigilance. Performance improved if the watch was interrupted by the subject leaving the test room or by the display being turned off while he remained within the test room (Jenkins, 1959). Solandt and Partridge(1946) agreed with this finding (Bergum and Lehr, 1962).

According to Buck (1966) uninterrupted and prolonged vigilance sessions were basic requirements for showing performance decrement: even a short pause during a session could serve to prevent the appearance of a decline or enhance the performance to its previous level. McCormack (1958) presented a light signal irregularly to subjects. He found reaction time to increase during a 40-minute session. However, after 5 to 10-minute interruptions in 2 separate groups of subjects, reaction time decreased and in the case of the 10-minute interruption, was almost returned to its original level. With regular presentation of signals the effect of interpolated rest was negligible because there was negligible decrement (Buckner, 1963 in Buckner and McGrath, 1963.) Buckner also said that with irregular intervals, if the interpolated rest period was too long, forgetting would occur and subjects would begin closer to their initial effort than would have occurred had it been shorter. According to Jerison and Pickett (1963):

Jenkins'/..

> Jenkins' (1958) preliminary work, which has been used to illustrate the effect of signal intensity, ... showed a decrement, and this work used successive 15-minute vigils separated by rest periods of at least 10-minutes. (Jerison and Picket, 1963, p. 229.)

Similarly, Mackworth and Taylor (1963) did not find a pause of 2-minutes every 10-minutes to have any effect on the detection of a brief pause in a circling clock hand (Mackworth J.F. 1964b). According to Jerison and Picket (1963):

> It would appear then that the pattern of breaks might be important and an alteration between rest and work in cyclic patterns might have the same effect on continuous work, whereas a single break might stand out (as figure against ground) and serve more adequately to moderate the onerousness of the vigil (Jerison and Picket, 1963, p. 229.)

Among those who found that rest pauses served to combat decrement of performance was Jenkins (1958), cited by Buck (1966), who required subjects to

> ... detect exceptional deflections of an oscillating voltmeter pointer and to respond to a peripheral light signal reaction times to the light signal increased with time on task in an uninterrupted session of 90 minutes, but this was not the case when subjects were interrupted for 30 seconds every 5 minutes. (Buck, 1966, p. 293.)

Others finding the same were Adams (1956) who found that detection rate decrement in a 110-minute session was followed by a significant improvement after a 10-minute rest pause. Also, Colquhoun found that the marked decline during the second half-hour of a detection task was prevented when a pause of 5-minutes was introduced at the end of the first half-hour (Mackworth, J.F., 1964b).

Similarly/...

Similarly, Wilkinson (1954b) demonstrated that 30-second rest pauses every 5-minutes were enough to maintain the level of performance in a 5-choice task (Mackworth, J.F., 1964b). Finally, Bergum and Lehr (1962) showed that rest pauses every half-hour were sufficient to maintain vigilance performance in a monitoring task with both high and low signal rates. Bergum and Lehr's results demonstrated how effective relatively brief rest intervals were in maintaining high performance. When using Mackworth, N.H.'s schedules their results were similar in one experiment but with only $\frac{1}{3}$ the amount of rest. This suggested that the least facilitative length of rest period may be well below the 10-minutes employed in most studies.

Taking into account what has been stated above about the pattern of breaks and their length, the "effect" of an interruption then is to initiate a period of recovery of vigilance (Buck, 1966). Thus, according to Mackworth, J.F. (1964b):

> When rest periods intervene, the level which performance would have reached if there had been no decrement may be indicated by performance after the rest, and the decrement may be reflected in the amount of recovery during rest, although forgetting and other processes may have occurred and also the amount of recovery will be related to the length of the rest pause. (Mackworth, J.F., 1964b, p.216.)

Because/...

Because interpolated rest has this "recovery effect" upon performance, the present task did not allow the subjects any such rest during their vigil.

PRESENCE OF THE EXPERIMENTER

Frazer (1953), cited by Baker (1959a), and Hardesty, Trumbo, and Bevan (1963) found that the presence of the experimenter or the introduction of an authority figure "monitoring the monitor" facilitated performance if he sat quietly behind the observer rather than outside the room. For this reason the experimenter controlled the task from a room outside the test room.

INDIVIDUAL DIFFERENCES

Sipowiz, Ware and Baker (1962) put much inter-subject variability causing inter-subject performance differences as due to motivational differences and, they suggested, were thus susceptible to experimental manipulation and control. Similarly Witkin (1950) had found a marked range of differences among subjects in the quantity of difficulty encountered in his EFT, the range was even greater for women.

Jerison and Pickett (1963) concluded that vigilance performance was highly variable between individuals and that no satisfactory analysis of the sources of this variation had been reached. Similarly, Buckner, McGrath, and Harabedian (1963, in Buckner and McGrath, 1963) found:

1/...

1. a great extent of individual differences on vigilance tasks and their stability over extended time periods;

2. a rise in extent of individual differences from alerted to watch standing conditions and as the watch progressed;

3. a low correlation between individual performance on visual displays devised for different sensory modes;

4. a relatively high correlation between individual performance under watchstanding and alerted conditions.

Individual differences thus exist in vigilance performance over time. For this reason the results of one subject could not be considered to reflect average performance. Rather a random sample of male students was picked from the university corridors and the means of their scores on the variables under consideration were calculated.

INTELLIGENCE

Kappauf and Powe (1959) found one significant correlation ( $r=30$ ) out of four between intelligence and vigilance performance. On the other hand, Solandt and Partridge (1946), Mackworth N.H. (1950), McGrath, Harabedian and Buckner (1960), and Ware (1960), all cited by McGrath (1963) in Buckner and McGrath (1963), found no significant relation between measures of general intelligence and vigilance performance. Neither did Baker (1959b) but he said: "Data however are few". Because of this, and because subjects

were/...

were all university students, the present project did not study intelligence as a performance variable of vigilance.

SEX DIFFERENCES

Witkin (1950) found females to be more variable than males in their performance on the EFT. Bieri, Bradburn, and Galinsky (1958), like Witkin (1950), have found males to be superior to females on tests of spatial relations. However, Goldstein and Chance (1965) found this difference between males and females to disappear by the final trials while Jackson, Messick, and Meyers (1964) found no such differences. [For further details consult Chapter 2.]

Taub and Osborne (1968) found females to be more able than males to maintain performance over an extended period of time; this was in agreement with Whittenberg, Ross and Andrews (1956 ). McCormack (1960) and McCormack and Prysiazniuk's (1961) studies however revealed no sex differences relating the slope parameter of the function relating reaction time to task duration or the length of the interstimulus interval.

In this study, it was decided to use subjects of one sex, namely males to eliminate any effects sex differences might have on either vigilance or embedded figures test performance.

AGE

Axelrod and Cohen (1961) cited Basowitz and Kerchin (1957) and Crook, Alexander, Anderson, Coules, Hanson and Jeffries (1958) as having reported that senescents performed worse than young adults on versions of the Gottschaldt task. Similarly, Axelrod and Cohen found young adults to perform better on visual and tactile hidden figures tests than senescents. Witkin et al (1962) considered that field independence increased with age and they found that field independent persons responded better to driving situations. Goldstein (1961) confirmed this by showing older drivers to perform better and those below 25 years of age to perform poorly. He however also showed that those above 65 years of age also performed poorly (Barrett and Thornton, 1968). Similarly, Schwartz and Karp (1967) recently found older individuals to be field independent (Barrett and Thornton, 1968 ). The latter 2 researches reasoned that while the younger group had faster reaction times, this was cancelled out to a certain extent by the real-world situation which involved a complex perceptual element requiring the intruding object to be recognised before any action could be taken. [For further details consult Chapter 2.]

According to Talland (1966) the evidence for any effect age had on vigilance performance seemed to clash and depended greatly upon experimental procedure. He said that performance deterioration in tasks with low signal frequency and signal to event ratio occurred with time and noise rate and expanded with age. Surwilla and Quilter (1964) have/...

have shown this but Talland (1966) cited Canestrari (1962) and also Davies and Griew (1963) who did not find this. There appeared, Talland (1966) said, to be no conclusive evidence that a fast pace *per se*, with or without a high signal frequency, raised the difficulty of detection more for older adults than for younger people. Kirchner (1958) and Weford (1962), cited by Tanner (1966), attributed this decline in performance with age on unpaced sequential tasks to failures in short term memory. Talland's experimental results agreed with the finding that continuous performance in signal detection did not decline with increasing age below the age of 60 years as long as the events occurred at a relatively slow rate. Accuracy declined progressively at a faster rate with each successive decade with a decided decline at about 40 years of age and then again at about 60 years. The above effect of the faster rate, said Talland, was present even though the task did not require retention of information from previous displays and so poor short-term memory in no way caused decrement. He concluded that the rate of display change was the vital factor in decreased accuracy with increasing age. And further, this seemed to arise from the requirement to scan the constantly changing displays and from making repeated decisions on the selection and indication of those that had a signal property. Results however were conflicting.

Because of the conflicting results regarding performance on vigilance tasks at various ages, the variable of

age/...

age was kept an unimportant between subject performance variable. This was achieved by choosing all subjects from a small range in age - namely, 19 to 22 years of age. These were also the subjects most readily available for experimentation.

EXTRANEOUS SOUNDS

It is generally true that frequent changes in conditions do not allow human performance to settle to a level characteristic of each condition (Babington - Smith, 1951). Extraneous sounds could have an arousing or distracting effect (Mackworth, J.F., 1969). Corcoran (1962b) found that such sounds could increase arousal and so performance (Davies and Hockey 1966). Mackworth, J.F. (1969) said the harmful effect of extraneous sound may be greatest at the end of an unchanging task. Broadbent (1963) suggested 2 possibilities in Buckner and McGrath (1963):

1. Like Mackworth, J.F. (1969), he said that continuous extraneous sounds were not arousing and prevented sounds from providing a variety to the background and so lowered arousal.
2. The sounds, he said, were too stimulating and the inverted U-shaped relationship held as there might be an increasing tendency to respond to irrelevant stimuli.

Bevan, Avant, and Lankford (1967) found that constant sound above the level of the sounds from the test room had no effect upon detection probability in a visual monitoring task. However, adding variable sound of the same average intensity reliably enhanced performance.

Broadbent (1963), in Buckner and McGrath (1963), and Jerison and Wing (1957), cited by Broadbent, found extraneous sounds to be detremental to performance in tasks involving several different signal sources. Jerison and Wing found no significant differences in performance in conditions with extraneous sound and in conditions of quietness over a 105-minute period. They concluded that "flexibility of attention might be affected by noise" while vigilance tasks not requiring this flexibility "may be unaffected". That is, tasks where subjects required to scan a series of displays in addition to maintaining a vigil of each showed a decrement in conditions of extraneous sounds as opposed to those using a modified "Mackworth Clock Test". Thus, they reasoned, performance in a one-clock test might be put down to alertness and focusing while performance on more complex tasks might be due to flexibility and alertness. This, they said, suggested that vigilance, in the sense of maintenance of attention level or alertness, was not affected by extraneous sounds and that the place to seek the deleterious effect found in complex tasks was in flexibility of attention - e.g. in the extent the



subjects/...

subjects carried on scanning the displays they were required to monitor.

It appears that auditory sounds just above the sound of the apparatus would not become a major factor leading to decrement in a task like the present that did not involve flexibility of attention. Such sounds would merely eliminate extraneous sounds which might distract or alert the subject. The present experiment used white noise in an attempt to eliminate these extraneous and distracting or stimulating sounds.

## SUMMARY AND CONCLUSIONS

Response time has been shown to be linearly related to stimulus uncertainty and so would increase over time on the task the more uncertain the subject was of the critical signals' temporal distribution. Thus, irregular intervals between signals resulted in performance decline as temporal expectancies could not easily be built up or learned. With an increase in signal rate reaction time decreased, but with irregular signals at low density, that is, with rare signals, performance decline would be marked. Maximum performance decrement could thus be predicted with signals at low frequency or rate which were irregularly spaced in time. A positive relation between detection rate, signal rate, and probability of detection has been found. Thus in the present study in order to obtain a decrement in performance

over/...

over a period of 2-hours, an irregular time interval between critical signals at a low frequency or rate was drawn up in the following way: the simple figure was not necessarily present in each complex figure presentation as was the case in Witkin's (1950) EFT. In an attempt to reduce the effect of practice the present task, like Witkin's EFT, used a large variety of test figures which included Witkin's figures and similar figures. In neither tasks were the complex and simple figures presented simultaneously. Unlike Witkin's task, it was decided to keep the sequence of simple figures stable throughout the study: only the simple figures present in complex figures ,their order of presence, and the order of the shape of the complex figures changed for each sequence of simple figures.

The practice of projecting the complex figure first and a different simple figure on each trial was intended by Witkin to impress the total complex pattern upon the subject and to discourage searching for a specific simple figure. In a preliminary study by Witkin (1950) the presentation of a simple figure was followed by a series of complex figures in which it appeared. Here Witkin found subjects able to attend to a segment of each complex figure disregarding its over-all pattern. This attitude was aided by the location of the simple figure, in whole or in part, near the centre of the complex figure. Further, the repeated search on successive trials for the same simple figure induced a specific "set" towards that particular figure (Witkin, 1950).

The/...

The final procedure developed by Witkin was used in the present study . [This was later modified as it tended to negate the property of irregularity of signal appearance: learning was also reported to occur.] Witkin graded his figures in difficulty. As grading was unimportant in the present task, no attempt was made to uphold it or formulate a revised version.

The present task allowed a maximum of 3-minutes as opposed to Witkins 5-minutes, for the subject to signal the simple figure's presence or absence in the appropriate complex figure. This was because the longest time required for a solution on Witkin's (1950) task was 156,8-seconds and because the timers used in the present study could only time out a maximum of 3-minutes each. The other times used and their order and application were the same as for Witkin's (1950) EFT based on his above findings concerning order of presentation. [The first 15-second presentation of the complex figure was later discarded in the present study for the reasons above.]

Knowledge of results (KR) enhanced performance and so the present task did not supply subjects with this knowledge. Unlike Witkin's (1950) EFT, the present task did not require the subject to trace out the simple figure in the complex figure with actions when he thought he had located it, nor was he allowed more than one overt attempt per trial before proceding to the next complex figure.

In/...

In both tasks the next complex figure in the series could be presented without the subject responding if he failed to reach a conclusion within the maximum time limit. Each subject obtained KR of performance in Witkin's (1950) EFT by being allowed an unlimited number of attempts to trace out the simple figure contained in the complex figure until correct or until 5-minutes had expired. Because of the possibility of being exposed to the same figure or similar figures later during the present 2-hour vigil each subject was given no indication of whether his responses were correct or incorrect. Further, subjects were allowed one overt response or no response, either of which, whether the former was correct or incorrect, served as signals for the next sequence of figures. Thus, if the subject always responded within the 3-minutes searching time, the present task became self-paced.

With the progression of time on the task detection probabilities decline, response time, detection thresholds and observing response rates rise when there is temporal uncertainty of the critical signal and no KR. It was hypothesised therefore, that in the present task of an uninterrupted 2-hours, there would be some performance decrement. The length of 2-hours was selected on the basis of its frequent use in vigilance tasks. Further, to enhance decline in performance over time subjects were informed of the length in time of the task. The task was uninterrupted as the "effect of an interruption is to initiate a period of recovery of vigilance" (Buck, 1966) which would defeat the purpose of the task.

The time of day when each subject was tested was not compared between or within subjects as each was tested once only,in the afternoon. This was because the afternoon was the most convenient time and because results are conflicting regarding the effect of time of day on performance. This variable was thus kept constant.

Testing was undertaken at normal ambient room temperature as temperature extremes had been shown to have a detremental effect upon performance.

In Witkin's (1950) EFT each subject performed the task in the experimeter's presence. In the present study, typical of vigilance tasks, each subject was alone in the test room. There was no contact between him and the experimenter during the 2-hour task. The reason was because the presence of the experimenter had been shown to facilitate performance.

Individual differences in performance occur over time on a vigilance task. These were not considered in the present study. Rather, results of the sample were averaged to demonstrate any decline in performance over time.

Relations between intelligence and vigilance have been shown but there is little data. Also, because the subjects were all university students, it was decided not to include intelligence as a variable influencing performance.

Males have been shown by some to be superior to women on the EFT and others have shown this superiority to disappear over time.

Further/...

Further, women have been shown to be more able than men to perform over extended time periods which may account for the disappearance of men's superiority on the EFT. These results influenced the decision to use males only on the present task.

Because of the conflicting results regarding performance on vigilance tasks at various ages, age was kept an unimportant performance variable by selecting subjects whose ages ranged between 19 and 22 years of age. These were also the subjects most readily available.

Auditory sounds just above the sounds of the apparatus do not appear to be a major factor causing performance decrement where flexibility of attention is not a task requirement. Such sounds merely eliminate extraneous and distracting or alerting sounds. The present task, which did not require flexibility of attention used white noise to perform this very function.

# CHAPTER IV

# FIRST PILOT STUDY

# CHAPTER IV

## FIRST PILOT STUDY

It was clear the method of the present study was going to be important. Formulae had to be arrived at which preserved the essential features of Witkin's method, while not going beyond the capabilities of the available equipment. At the same time, it was desired that the study was not merely to be a development of the method. The best research strategy to fit the problem was therefore required. This choice of strategy influenced the details of the design and of operations for measuring and manipulating variables. Further, once formal data collection had begun, no further modifications to the strategy could be made. This was because data collected at one time would be incompatible with data collected at another. For these reasons pilot work was undertaken to help clarify the feasibility of the study and the potential adequacy of alternative methods, to refine techniques, and to raise problems the researcher might encounter in developing the final design. Pilot work was also undertaken to give the experimenter initial practice in testing subjects, so that in the final study they would all be treated alike.

Similarly, the presentation of data was aided and a hint to the study's final outcome was also provided. (Scott and Wertheimer, 1966).

Bearing in mind the points of the previous chapter the apparatus for the first pilot study was assembled with a view to the following operations in order to test the effects of performance decrement over time on an embedded figures test. This vigilance task kept the critical to non-critical signal ratio low by presenting numerous critical and non-critical sequences of slides (complex, simple, and the same complex slide) on a projection screen for 15, 10, and 180 - seconds respectively. This 180-second period was the maximum time allowed to respond for each sequence where the task of the subject was to indicate (by closing either of 2 appropriately labelled response switches) the presence or absence of the simple figure in the complex figure. This terminated the sequence and signalled the display of the next sequence of complex, simple, and complex slides. The time sequence of the various operations was recorded as was the nature of the responses (correct, incorrect, or no-response). This continued uninterrupted for 2-hours. Ideally the task should have been performed in a sound - proof room but since such a room was unavailable extraneous noises which might have influenced performance were masked with white noise. Each subject was tested seated in a darkened test room. The experimenter controlled the task from the adjacent control room connected to the test room by an interleading hatch.

## APPARATUS

1. BRS 300 and two 24 VDC Power Supplies.

2. Two Kodak Carousel S Projectors with 100 mm lenses to project slides.

3. Slide trays containing slides of simple and complex geometric figures.

4. Projection screen.

5. Three-Pen Recorder with 2 labelled response switches.

6. White Noise Generator and earphones.

7. Test and control rooms.

### 1. BRS 300 AND TWO 24 VDC POWER SUPPLIES

The BRS 300 Series Digibits offers plug - in logic modules with solid - state circuitry. These modules can be assembled into networks with pluggable patch cords by converting the presentations of logic functions to an operative system. All input and output connections are made at jacks on the front panel. All power connections are automatically made when the elements are plugged in.

The BRS 300 was programmed to co-ordinate the operation of the Three-Pen Recorder, the projection of slides by the 2 Kodak Carousel S Projectors, and the 3 timers and latching relays. This produced the following sequence. Projector number I projected a slide of a complex figure for 15-seconds. This was followed by Projector number II's projection of a simple figure for 10-seconds.

Projector/...

Projector number I then projected the same complex figure again till terminated by the closing of either of the response switches. This was also the signal to initiate the display of the next sequence of 3 (complex, simple, complex) slides. The BRS 300 also controlled 3 pens of the Recorder on which the time sequence of the various operations was recorded. This procedure continued for 2-hours without interruption. [See Appendex 2 for a detailed description of the circuitry.]

2. TWO KODAK CAROUSEL S PROJECTORS

Each circular slide tray of the Carousel S Projectors accommodated 80 slides. The transparent covers protected the slides against dust and damage when not testing.

Each projector was operated and timed by the BRS 300 through remote control cables fitted to the projectors.

Two slide trays were used with each projector : one contained 1 simple practice figure, another 8 simple test figures, the third 2 complex practice figures, and the fourth 80 complex test figures. Two of the trays required the modification discussed below.

For the practice trial the first practice simple figure was inserted in slot number 1 for the first presentation. During the presentation of the complex figure the simple figure was moved to slot number 3 for the second presentation.

After the second practice trial the trays of practice simple slides were removed and replaced by a tray of 8 simple test figures (Projector I) in slots 1, 3, 5, 7, 9, 11, 13, 15, and 17. The reason for the alternate slots was because the BRS 300 was reprogrammed in such a way that this projector, Projector I received 2 pulses, one when its light was switched on and the other when its light was switched off. The tray of practice complex slides in slots 1 and 2 of Projector II was removed after the practice session and replaced by the tray of 80 test complex slides in slots 1 to 80. The 2 trays containing the test slides were each given an extra slot by cutting away the covering of slot 0 to enable continuous slide presentation: the complex slides were each moved back one slot in their tray after each's presentation - e.g. 1 to 0, 2 to 1, and so on so that on their second presentation slide number 1 was projected from slot 0 and so on. Similarly, the simple test slides were moved forward in each case with slide 1 in slot 1 moved to slot 19, slide 2 in slot 3 to slot 21 and so on. The slots numbered 0 were blank on the insertion of each slide tray onto a projector as there was no support below to prevent slides in these slots from falling out. Slide 1 in slot number 1 was always projected first in each case because when the BRS was activated the tray of complex slides was pulsed to slot 1 and so for the simple tray when its turn followed till the task's completion at the end of 2 - hours.

Each of the 2 projectors projected from positions above the head of a seated subject. They were mounted one above the other on a stand in the control room and successively projected through a hatch onto the centre of the projection screen in the test room. (Fig. 2.)

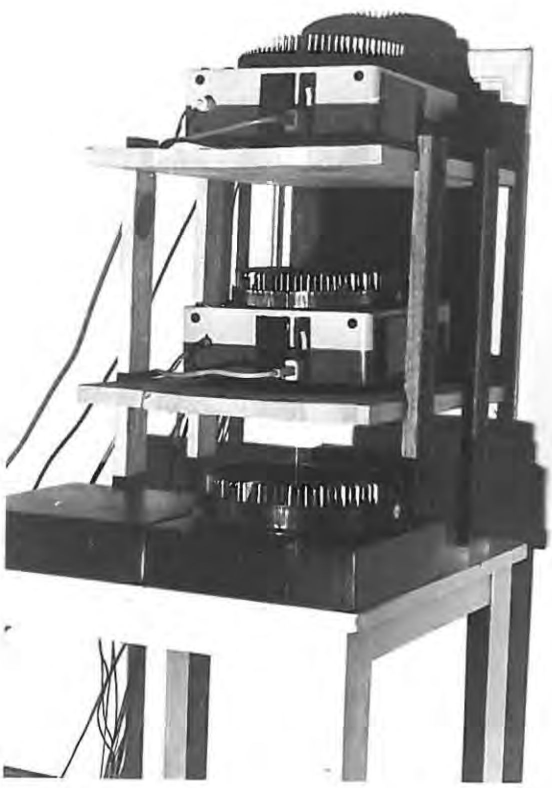


Fig. 2. Mounted Carousel S Projectors .

3. SLIDES

Slides of complex and simple geometric figures were made in the following way:

In Witkin's (1950) collection of figures each complex geometrical figure had its simple geometrical figure incorporated into its patterns so that the outline of the simple figure may form part of the boundaries of several subpatterns in the complex figure.

The present series however included Witkin's complex figures, e.g. Fig. 3b, which were the critical signals as well as similar figures into which the simple figures, e.g. Fig. 3a, could not be fitted. This was because one or more of the boundary lines of the simple figures had been omitted and other straight and wavy lines had been added, e.g. Fig. 3c. These wavy lines, to indicate colour in Witkin's (1950) straight line drawings, were kept in the present drawings to vary the stimuli by adding not only to the numbers of lines but also to the kinds of lines. These additional slides were used to provide the non-critical component of the vigilance task.

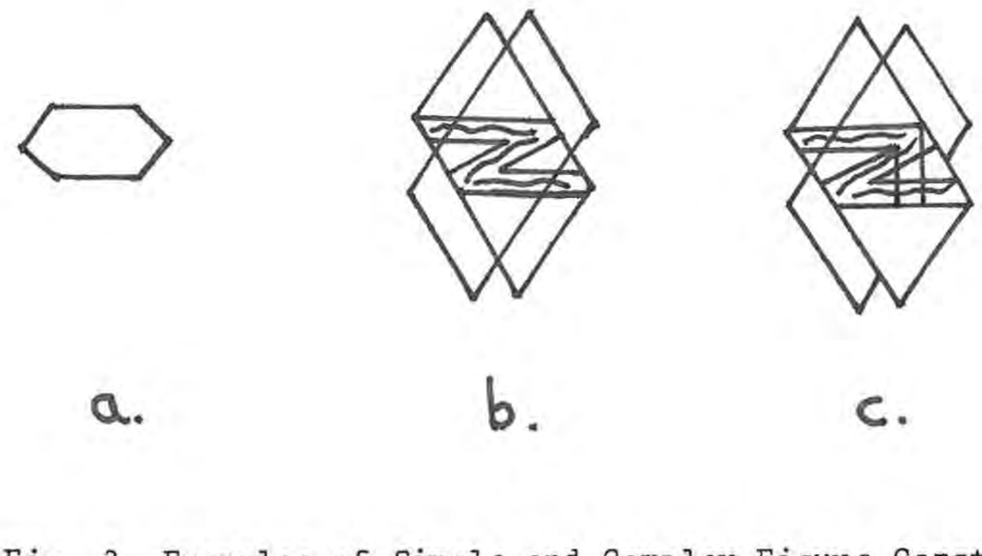



Fig. 3. Examples of Simple and Complex Figure Construction.

Witkin's (1950) series consisted of 1 practice simple geometrical figure with a practice complex geometrical figure into which it fitted and 8 simple test figures with 24 test complex figures into each of which 1 of the 8 simple test figures fitted. For the present study figures were drawn in black ink on white paper in sizes relative to Witkin's (1950) figures, but magnified. ( Appendix 9). These, when projected, were 12 times bigger than Witkin's. The present task consisted of Witkin's practice simple figure, 2 practice complex figures, the practice simple figure being incorporated only into Witkin's original practice complex figure. The test comprised of Witkin's 8 simple test figures with 80 test complex figures consisting of Witkin's original figures and the additional similar ones; only in Witkin's original 24 complex test figures were simple figures incorporated. [Fig. 1 for diagrams of Witkin's (1950) figures.]

These practice and test figures were photographed in the following way:

The mid-point between the readings of a light-meter for black and white paper was taken as the *f* stop for the camera. This was *f* 5, 6. At a distance of 1,9 feet vertically above the figures, using black and white film of 400 ASA with the camera set at the above *f* stop, the figures were photographed in diffuse sunlight with a shutter speed of $\frac{1}{125}$-second. Each spool of film was then developed for 12-minutes using Kodak D-76 developer, washed in a stop bath of 3% acetic acid, fixed for 4-minutes in Amfix, washed for 10-minutes to clean, allowed to dry, and then cut into slides. These slides, when projected onto a screen, were white outlines against a uniformly black background as compared to Witkin's coloured designs.

The order and the notation of simple test designs was F,D,A,G,B,H,C,E. The notation of for example, complex slide F1 meant that simple figure F was present in complex figure F 1 while in D2a for example, simple figure D was not present as it was present in D2 and so on. [For the order of simple and complex figures see Table 46.] [For the designs of simple and complex figures see Appendix 9]

4. PROJECTION SCREEN

A projection screen was installed in the test room which was darkened during testing. The subject was seated facing the screen with his back to the projectors projecting through an interleading hatch between the control room and the test room.

5. THREE-PEN RECORDER AND LABELLED RESPONSE SWITCHES

Two labelled response switches lay on a table before the subject (Fig. 5). Switch 1 activated Pen 2 and Switch 2 activated Pen 3 of the Three-Pen Recorder (Fig 4) which was driven by the second 24 VDC Power Supply. Switch 1 was depressed if the subject saw the simple figure in the complex figure, Switch 2 was depressed if the subject wished to indicate that the simple figure was not present in the complex figure.

Pen 2 was used to indicate the speed of response to the presence of the simple figure while Pen 3 was used to indicate speed of response to its absence, whether the response was correct or incorrect.

Fig. 4·Three - Pen Recorder.

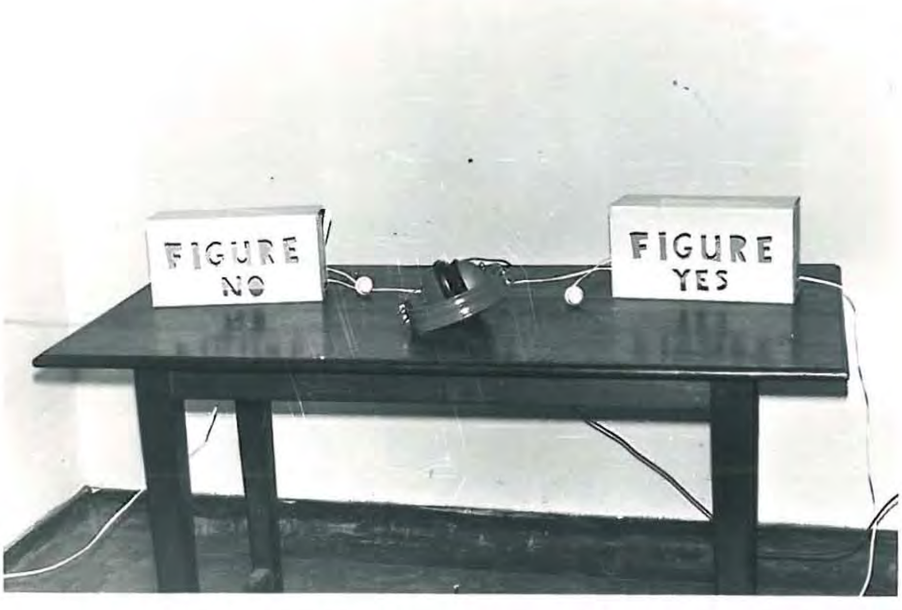



Fig. 5·Response Switches, Earphones and Labels.

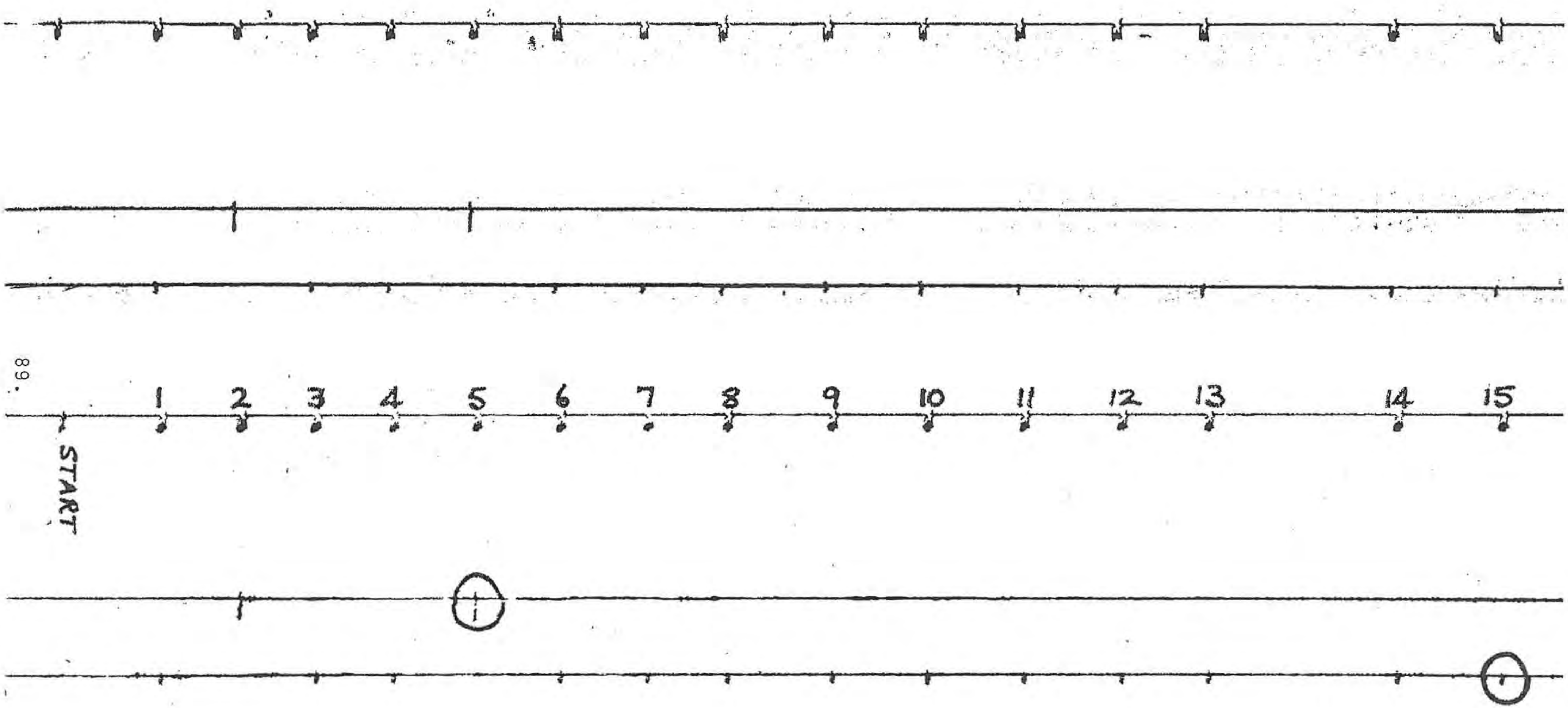



Fig. 6 Extract from a Graph Yielded by the Three-Pen Recorder.

Pen 1 of the Three-Pen Recorder recorded every time a new complex slide was flashed onto the screen: That is, either after the pressing of Switch 1 or Switch 2 or after the timing out of 3-minutes when the subject was unable to indicate the presence or absence of the simple figure. No response was indicated when no mark by Pens 2 or 3 followed a mark by Pen 1. (Fig. 6). Thus reaction time was measured from when the first slide of a sequence was flashed onto the screen as signified by Pen 1 until Pen 1 made its next mark which in turn served as the marker for the beginning of the next reaction time measure.

Two illuminated signs "Figure Yes" for Switch 1 and "Figure No" for Switch 2 were used to remind the subject which Switch to use throughout the task.

6. WHITE NOISE GENERATOR

The White Noise Generator (Fig. 7) installed in the test room fed white noise of 20 decibels to the subject through earphones (Fig. 5, Fig. 9).

Fig. 7. White Noise Generator.

## 7. TEST AND CONTROL ROOMS

All apparatus, other than the earphones and the White Noise Generator, the projection screen, chair and table, the 2 labels, the 2 response switches and wires leading to the BRS300 and the Three-Pen Recorder, was installed in the light control room. The adjacent test room was kept dark except for unavoidable slight illumination through an interleading hatch through which the slides were projected (Fig. 8). All electric wires from the test room were led into the control room through this hatch in the wall. The experimenter operated the equipment and controlled the experiment from the control room.

Fig. 8. Projectors and Interleading Hatch.

S U B J E C T S

The subjects of the first pilot study of the test were 2 male university students between 19 and 22 years of age selected at random from the university corridors. Each subject was seated in the test room and was not allowed to leave the room or smoke during the test. (Fig.9.).


Fig. 9. Subject Seated in Test Room.

P R O C E D U R E

With the apparatus switched on each subject was seated in a chair in the test room in a position facing the projection screen. Room temperature was ambient, The following instructions which were based on Witkin's (1950) were read to each subject:

> You are going to be shown a series of geometric designs on the screen before you. The designs will be white outlines on a black background. After each complex or large design you will be shown a simple or smaller figure which may be contained in the larger complex design just previously shown. You will then be shown the same larger design again and your task will be to locate the smaller figure in it. Do not trace the smaller figure manually. This smaller figure will not be present in the complex or larger figure in every instance. When present, it will always be in the same upright position, size and shape originally presented to you. This is the figure you must search for and respond to when located by pressing the response button before you on your left (Figure Yes). If you decide that the simple figure is absent press the button before you on your right (Figure No ). If you have not located the simple figure within 3 - minutes a new complex slide will automatically be flashed on to replace the other. Your score will depend upon your speed and accuracy of response, so work as quickly and as accurately as you possibly can. Avoid guessing. You will be given 2 practice runs, the first showing an example of a complex figure where the smaller figure is present and the second where the same smaller figure is absent. Throughout the study a number of different smaller or simple figures and complex or larger figures will be used. On the table before you are earphones from a white Noise Generator, these must be worn to cut out extraneous sounds. You may not smoke and must surrender your watch for the duration of the task.

> Are there any questions? [Experimenter answered questions.] You will have further opportunity for questions after your practice session. I will leave the room now with the door closed and the light switched off. Your practice session will follow. Put on your earphones.

After taking possession of the subject's watch the experimenter left the test room and closed the door after switching off the light. In the control room next door the BRS 300 was activated and the subject was shown practice complex figure P1 for 15-seconds. After P1 was removed practice simple figure P was shown for 10 - seconds. When it was removed P1 was shown again until the subject responded or for 3-minutes if he did not respond. P 1a was then projected for 15-seconds, then P, the same practice figure as above, for 10-seconds, and then P 1a again until the subject responded or for 3-minutes if he did not respond by pressing one of the 2 response switches . Then the apparatus, except the White Noise Generator and the 2 labels, was immediately switched off and the experimenter re-entered the test room and, first indicating for the subject to remove the earphones further instructed him as follows:

> Have you any questions? [Experimenter answered questions.] I will now leave you with your earphones on in the darkened room to begin the actual test. The test will last 2-hours without interruption. Have you any further questions? [Experimenter answered questions.] Put on your earphones.

The experimenter left the test room for the control room and switched on the apparatus after tearing off the trial graph on the Three-Pen Recorder to allow recording to begin on a clean strip of graph paper. The trial graph, merely to test whether the subject understood the instructions, was discarded. The beginning of each graph was marked by noting the subject's number - i.e., the first subject being subject number 1 and so on.

Upon switching the equipment on the BRS 300 was immediately re-activated by the experimenter to start the test sequence where a 15-second complex slide was followed by an appropriate simple slide for 10 - seconds and then the same complex slide again until the subject responded or for 3 minutes if he did not respond. Both instances signalled the BRS 300 to flash the next complex slide onto the projection screen. This sequence was continued uninterrupted for 2 - hours.

Two blank flashes occurred on the projection screen. The first was between the last practice trial and the switching off of the equipment. This was because the BRS 300 could not be stopped immediately after the last practice trial so that the next image projected was a test figure and not a blank flash. Another blank flash occurred between switching the BRS 300 on and activating it because, when the new trays of test slides were fitted, their first space, slot 0, did not contain the first slide to be projected. This was in slot 1.

## RESULTS

The graphs produced by the Three-Pen Recorder were divided into quarter-hour segments. The number of responses, average reaction time[*], the number of errors, the percentage of false reports, and the percentage of signals (simple figures occurring in complex figures) missed were read for each subject for each $\frac{1}{4}$-hour and tabulated. The means of these scores on each $\frac{1}{4}$-hour for the 2 subjects tested were calculated, tabulated, and plotted against $\frac{1}{4}$-hour divisions on graphs to outline the average trends of results. Time on the task in eight $\frac{1}{4}$-hour segments is on the horizontal axis while the particular variable being considered is on the vertical axis of each graph.

## DISCUSSION OF TABLE 3 AND GRAPHS 1A TO 1E

### AVERAGE NUMBER OF RESPONSES (GRAPH 1A, PAGE 102)

The average number of responses ranged between 35 at the $\frac{1}{2}$ and $\frac{3}{4}$-hour marks and 42 at the $1\frac{3}{4}$-hour mark with an average of 38,19 responses per quarter-hour. The difference between the beginning and end results was 5 responses. The average number of responses increased over time from 36,50 at the $\frac{1}{4}$-hour mark to 41,50 at the 2-hour mark.

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[*] Reaction time was measured from the beginning of each sequence of complex, simple, and complex slides until the subject responded or for 3-minutes whereupon a new sequence would begin with its own reaction time.

AVERAGE REACTION TIME IN SECONDS (GRAPH 1, PAGE 103)

The average reaction time in seconds ranged between 21,46 at the 1¾-hour mark and 25,80-seconds at the ½-hour mark with an average of 23,80-seconds per quarter-hour. The difference between the beginning and end results was 2,94-seconds. Average reaction time in seconds declined over time from 24,66-seconds at the ¼-hour mark to 21,72-seconds at the 2-hour mark.

AVERAGE NUMBER OF ERRORS (GRAPH 1C, PAGE 104)

The average number of errors ranged between 8 at the 1¼-hour mark and 11 at the ¼ and ½-hour marks with an average of 9,31 errors per quarter-hour.

The difference between beginning and end results was 1 error. There was an unsteady decline in the average number of errors over time from 11 at the ¼-hour mark to 10 at the 2-hour mark.

AVERAGE PERCENTAGE OF FALSE REPORTS (GRAPH 1D, PAGE 105)

These ranged between 5,73% at the 1¼-hour mark and 26,57% at the ½-hour mark with an average of 12,23% per quarter-hour. The difference between the beginning and end results was 14,90%. The average percentage of false reports declined over time from 21,69% at the ¼-hour mark to 6,79% at the 2-hour mark.

AVERAGE PERCENTAGE OF MISSED SIGNALS ( GRAPH 1E, PAGE 106)

This ranged between 44,23% at the 1¾-hour mark and 68,33% at the 1-hour mark with an average of 56,10% per quarter-hour. The difference between the beginning and end results was 12,28%. The average percentage of signals missed increased over time from 50,50% at the ¼-hour mark to 62,78% at the 2-hour mark. This increase was by no means smooth.

CONCLUSIONS

Subjects showed a rise in the percentage of missed signals, a decline in the percentage of false reports, number of errors and a decline in reaction time with an accompanying increase in the number of responses with the progression of time on the task. The increase in the percentage of missed signals was of critical importance to show performance decline.

By consulting subjects after the task it was found that they had been able to associate complex and simple figures after repeated presentations ,and knew which simple figure to look for in each complex figure before the simple figure's presentation. It is possible that this evidence of learning influenced performance. The practice of projecting the complex figure first and then the simple figure and then the complex figure again on each trial was intended by Witkin (1950) to impress the total complex pattern upon the subject,and to discourage searching for a specific simple figure. He intended this procedure to

increase/...

increase the attention to the overall complex pattern and so to increase the task's difficulty. In the present task, the subjects were able to learn which complex figure accompanied which simple figure because the same complex figures were presented a number of times, as opposed to Witkin's task where each was presented once. Consequently, after a few repetitions subjects were able to look for the anticipated simple figure in the complex figure before the simple figure was presented to them. This served to decrease their response time. After a while they could tell by a mere glance at the complex figure whether or not it would contain the appropriate simple figure. For this reason the first 15-second presentation of the complex figure was discontinued and the BRS 300 was reprogrammed in an effort to obtain performance decrement. The revised apparatus and procedure to conduct a second pilot study for the reasons given above took the form documented in the following chapter.

Table 1. Subject Number 1.

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen - tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 37 | 24,32 | 10 | 15,38 | 54,55 |
| ½ | 38 | 23,68 | 11 | 7,69 | 75,00 |
| ¾ | 40 | 22,50 | 10 | 7,14 | 66,67 |
| 1 | 41 | 21,98 | 8 | 0,00 | 66,67 |
| 1¼ | 40 | 22,50 | 8 | 3,45 | 63,64 |
| 1½ | 40 | 22,50 | 10 | 10,71 | 63,33 |
| 1¾ | 42 | 21,46 | 8 | 6,67 | 50,00 |
| 2 | 43 | 20,93 | 11 | 6,67 | 62,23 |

Table 2. Subject Number 2.

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen- tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 36 | 25,00 | 12 | 28,00 | 45,45 |
| ½ | 32 | 27,91 | 11 | 45,45 | 20,00 |
| 8 | 30 | 30,00 | 8 | 19,05 | 44,44 |
| 1 | 34 | 26,47 | 11 | 16,67 | 70,00 |
| 1¼ | 36 | 25,00 | 8 | 8,00 | 54,55 |
| 1½ | 40 | 22,50 | 8 | 3,57 | 58,33 |
| 1¾ | 42 | 21,46 | 8 | 10,34 | 38,46 |
| 2 | 40 | 22,50 | 9 | 6,90 | 63,33 |

Table 3

Average Observed Results of Subjects Numbers 1 and 2.

| Average Observed Results | | | | | |
|---|---|---|---|---|---|
| Time in Quarter - Hour Divisions | Average Number of Responses | Mean of the Average Reaction Time in Seconds | Average Number of Errors | Average Percentage of False Reports | Average Percentage of Missed Signals |
| $\frac{1}{4}$ | 36,50 | 24,66 | 11,00 | 21,69 | 50,50 |
| $\frac{1}{2}$ | 35,00 | 25,80 | 11,00 | 26,57 | 47,50 |
| $\frac{3}{4}$ | 35,00 | 26,25 | 8,50 | 13,10 | 55,56 |
| 1 | 37,50 | 24,23 | 9,50 | 8,34 | 68,33 |
| $1\frac{1}{4}$ | 38,00 | 23,75 | 8,00 | 5,73 | 59,10 |
| $1\frac{1}{2}$ | 40,00 | 22,50 | 8,50 | 7,11 | 60,83 |
| $1\frac{3}{4}$ | 42,00 | 21,46 | 8,00 | 8,51 | 44,23 |
| 2 | 41,50 | 21,72 | 10,00 | 6,79 | 62,78 |
| Average per $\frac{1}{4}$ - Hour | 38,19 | 23,80 | 9,31 | 12,23 | 56,10 |
| Difference Between Beginning and End Results | 5,00 | 2,94 | 1,00 | 14,90 | 12,28 |

FIG. 10 GRAPH 1 A FOR TABLE 3
AVERAGE NUMBER OF RESPONSES

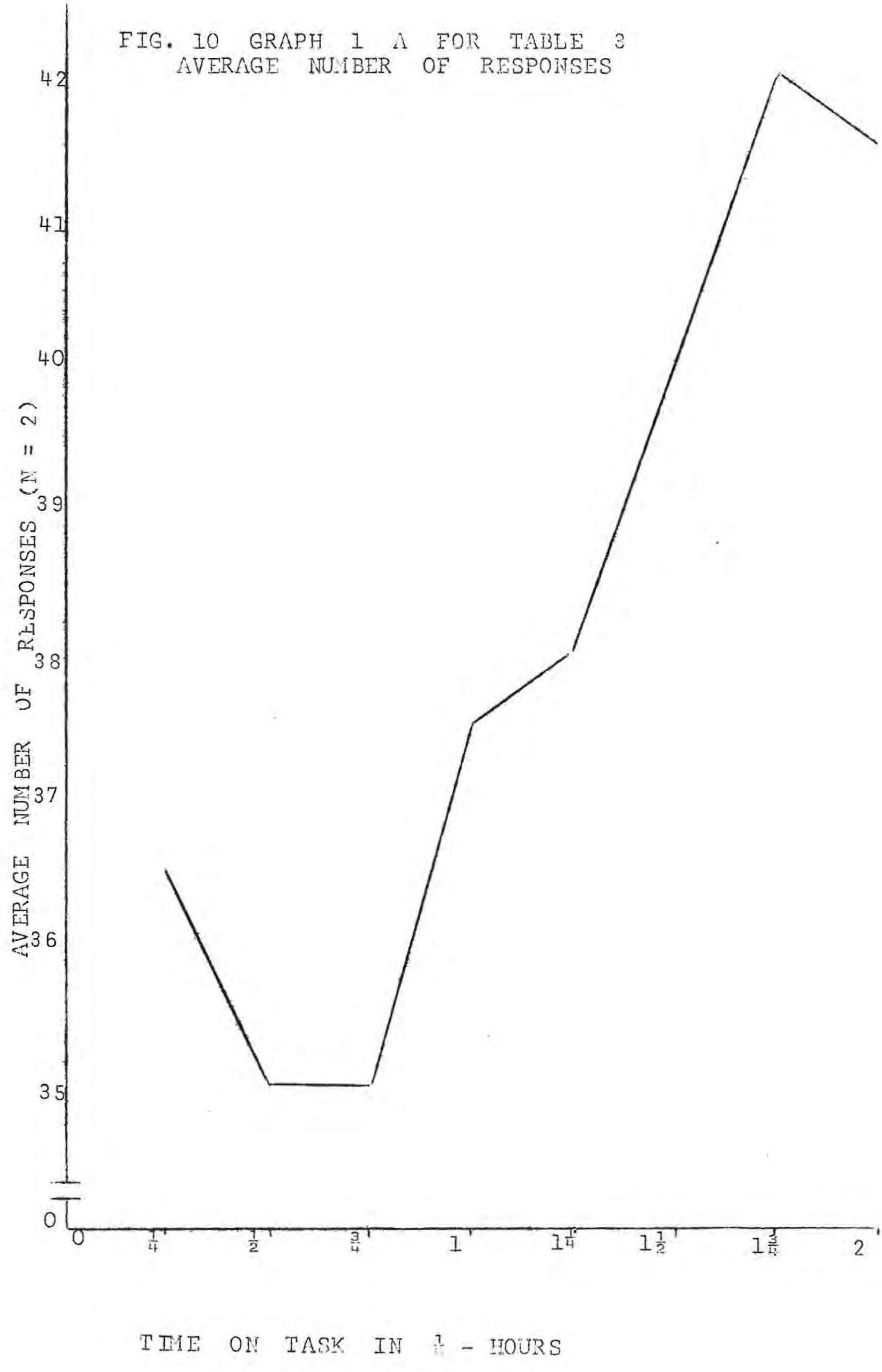


FIG. 10 GRAPH 1 B FOR TABLE 3

AVERAGE REACTION TIME
IN SECONDS

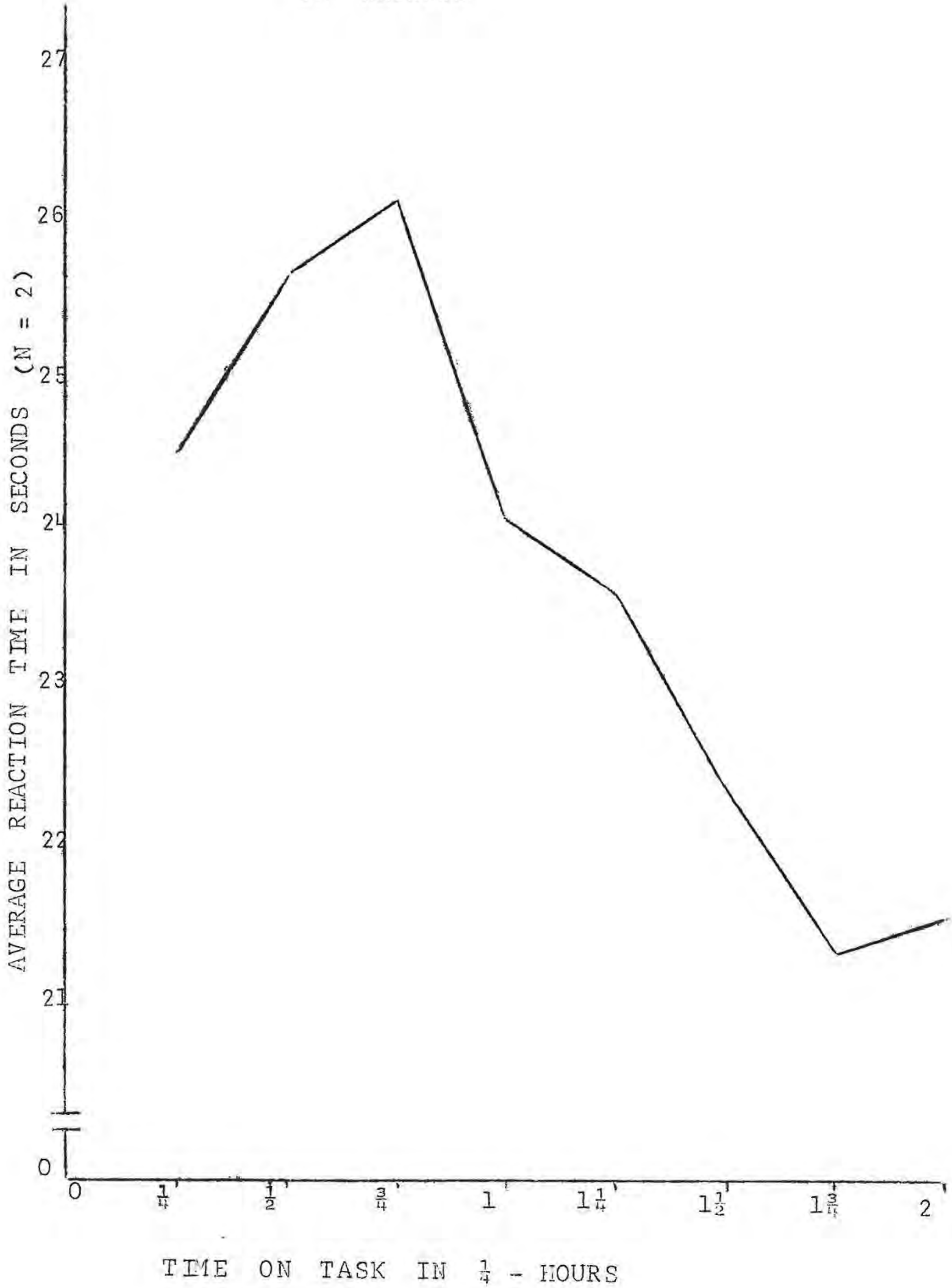


FIG. 10 GRAPH 1 C FOR TABLE 3

AVERAGE NUMBER OF ERRORS

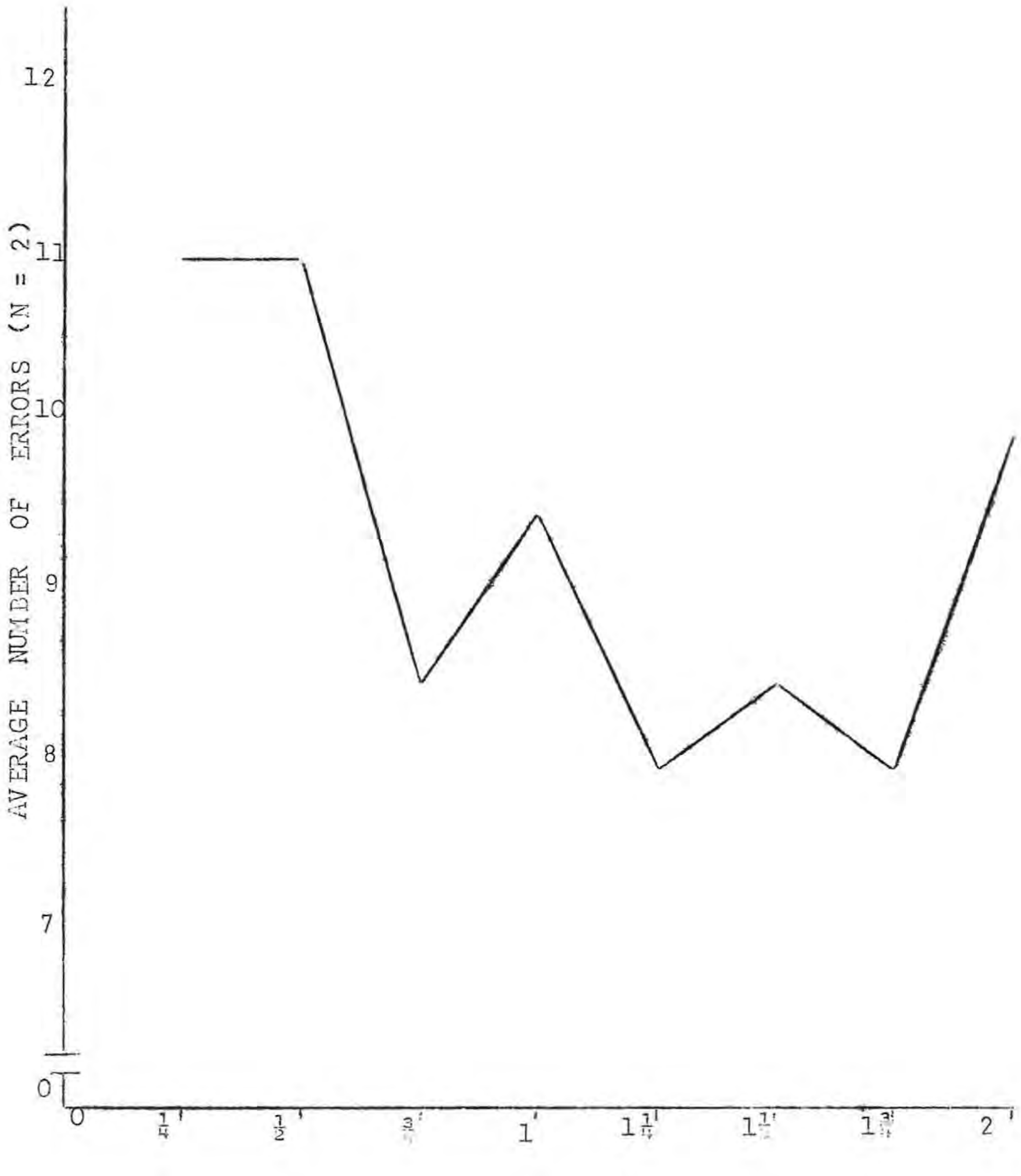


FIG. 10 GRAPH 1 D FOR TABLE 3

AVERAGE PERCENTAGE OF FALSE REPORTS

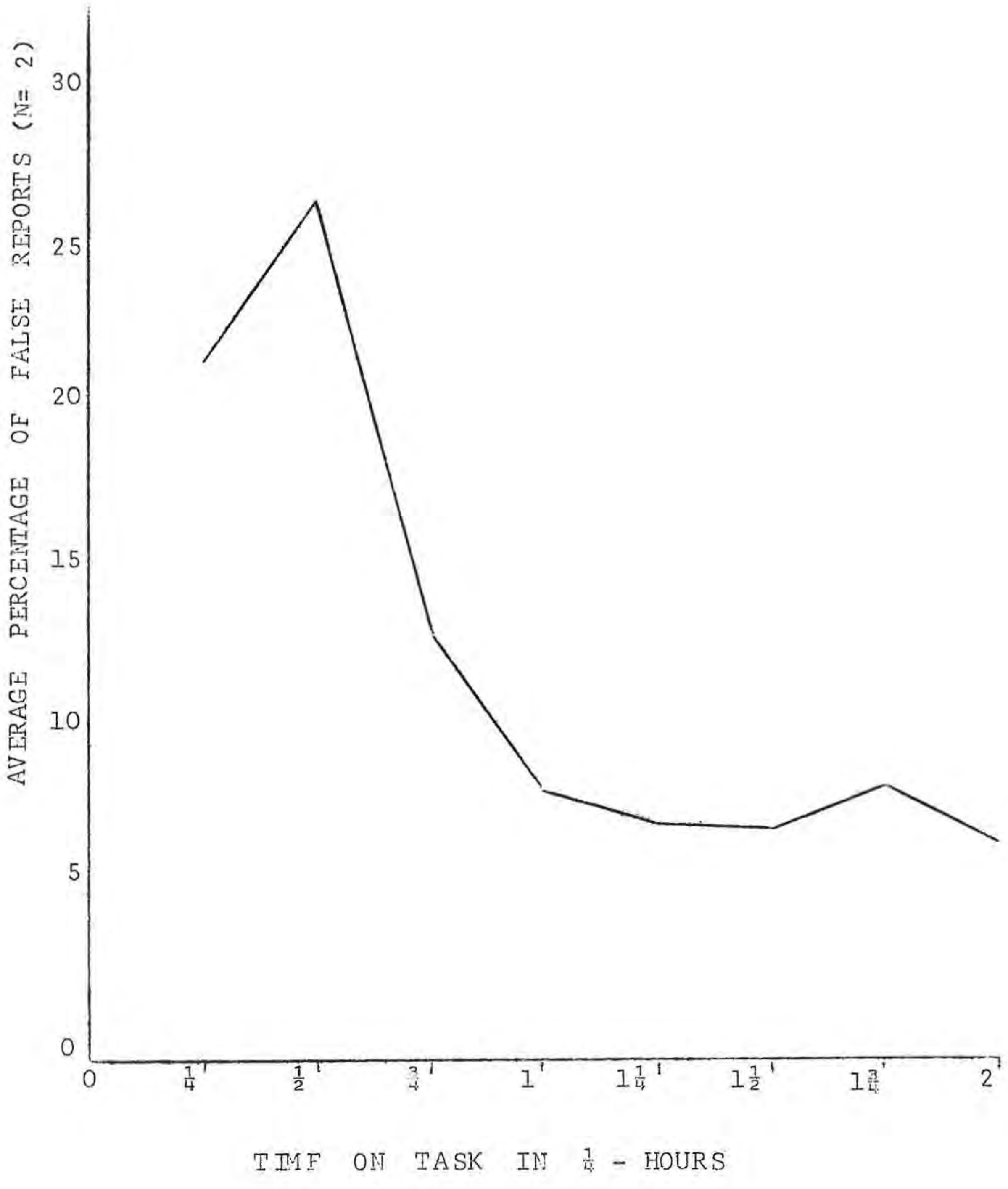
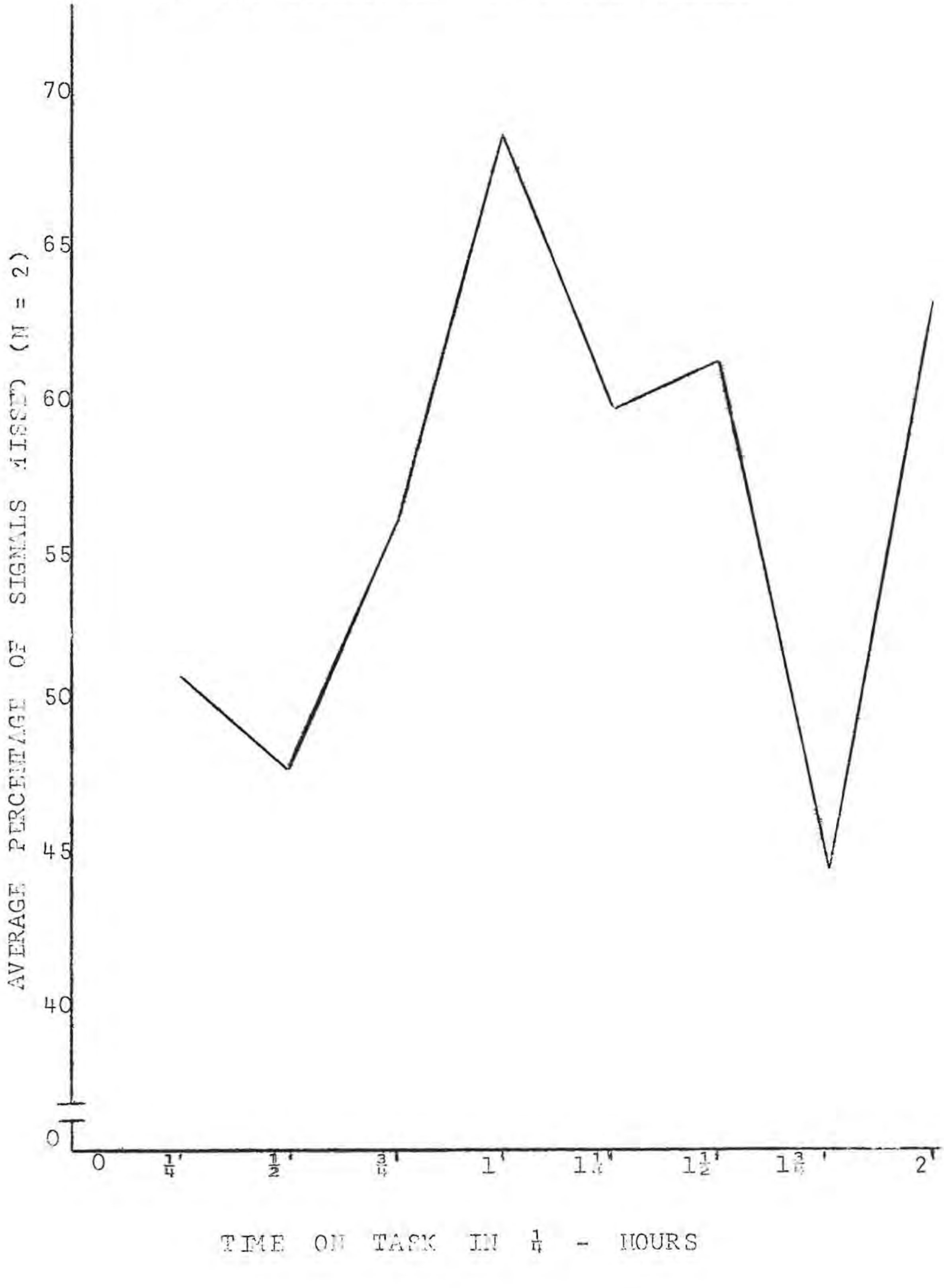


FIG. 10 GRAPH 1 E FOR TABLE 3

AVERAGE PERCENTAGE OF MISSED SIGNALS



# CHAPTER V

# SECOND PILOT STUDY USING THE FIRST REVISED METHOD

# CHAPTER V

## SECOND PILOT STUDY USING THE FIRST REVISED METHOD

There was no change in apparatus from the first method except for the re-programming of the BRS 300 to accommodate the new scheme of slide presentation. That is, the first projection of each complex slide for 15 - seconds was discontinued. After reprogramming the BRS 300 it was no longer necessary to place simple slides 2 slots apart in their slide tray as this tray now moved one space per trial in harmony with the tray of complex slides. [See Appendix 3 for a detailed description of the circuitry employed.] Accompanying this discontinuation of the 15-second presentation was a change in procedure and instructions. There were no changes in subject selection or the presentation and discussion of results except that only 1 subject was tested in the second pilot study.

### PROCEDURE

The following revised instructions were read to each subject

You are/.....

You are going to be shown a series of geometric designs on the screen before you. The designs will be white outlines on a black background. You will be shown a simple or smaller design and then a complex or larger design, the simple or smaller design may be contained in the larger design. Your task will be to indicate the presence or absence of the smaller figure in the complex design. When present, the simple or smaller figure will always be in the same upright position, size and shape originally presented to you. This is the figure you must search for and respond to when located by pressing the response button on your left (Figure Yes); if you decide the simple figure is not present, press the button on your right (Figure No). If you have not located the simple figure within 3-minutes a new simple figure will automatically be flashed onto the screen to replace the complex figure. Avoidguessing and work as quickly and accurately as you can as your score will depend upon the speed and accuracy of your responses. You may not trace the figures out manually.

You will now be given 2 practice trials: the first showing an example of a complex figure where the smaller is present and the second where the same smaller figure is absent. Throughout the study a number of different smaller or simpler and complex or larger figures will be used.

On the table before you are earphones from a White Noise Generator, these must be worn to cut out extraneous sounds. You may not smoke and must surrender your watch for the duration of the task. Are there any questions? [Experimenter answered questions.] You will have further opportunity for questions after your practice session. I will leave the room now with the door closed and the light switched off. Your practice session will follow. Put on your earphones.

After taking possession of the subject's watch the experimenter left the test room after closing the door and switching the light off. In the control room the BRS 300 was activated and the subject was shown the practice simple figure P for 10-seconds. When it was removed P-1, the first practice complex figure, was shown until the subject responded or for 3-minutes if he did not respond. P was then projected again for 10-seconds and then P 1a, the second complex practice figure,was projected until the subject responded by pressing one of the 2 response switches or for 3-minutes if he did not respond.

There were no further changes in procedure except that in the test, as in the practice trials, the BRS 300 initiated each sequence of slides which began with a 10 - second simple slide followed by an appropriate 3-minute complex slide or until the subject responded.

DISCUSSION OF TABLE 5 AND GRAPHS 2A TO 2E WITH A COMPARISON BETWEEN GRAPHS 1A TO 1E AND GRAPHS 2A TO 2E

Graphs 1A and 2A, 1B and 2B, and 1C and 2C could not be compared regarding the average performance per $\frac{1}{4}$-hour for 2-hours as the initial 15-second presentation of the complex figure had been discontinued for Graphs 2 .

NUMBER OF RESPONSES (GRAPH 2A, PAGE 117)

The number of responses ranged between 42 at the $\frac{1}{4}$-hour mark and 53 at the 1 and $1\frac{1}{4}$-hour marks with an average of 48,38 per quarter-hour. The difference between the beginning and end results was 10.

There/...

There was a rise in the number of responses over time on Graph 2 A from 42 at the $\frac{1}{4}$-hour mark to 52 at the 2-hour mark.

The lowest number of responses occurred at the $\frac{1}{2}$ and $\frac{3}{4}$-hour marks in Graph 1 A and at the $\frac{1}{4}$-hour mark in Graph 2A; the most responses in Graph 1 A occurred at the $1\frac{3}{4}$-hour mark while in Graph 2 A it occurred at both the 1 and $1\frac{1}{4}$-hour marks. Graph 2 A showed a wider difference between the beginning and end results, namely 10 as opposed to Graph 1 A's 5. Graph 1 A like Graph 2 A showed an overall increase in the number of responses over time.

AVERAGE REACTION TIME IN SECONDS (GRAPH 2B, PAGE118)

Average reaction time in seconds ranged between 16,98 at the 1 and $1\frac{1}{4}$-hour marks and 21,46 at the $\frac{1}{4}$-hour mark with an average of 18,77-seconds per quarter-hour. The difference between the beginning and end results was 4,15. There was a decline in the average reaction time over time from 21,46-seconds at the $\frac{1}{4}$-hour mark to 17,31 at the 2-hour mark.

The highest average reaction time in Graph 1 B occurred at $\frac{3}{4}$ of an hour and at the $\frac{1}{4}$-hour mark in Graph 2 B; the lowest occurred at $1\frac{3}{4}$-hour mark in Graph 1 B and at 1 and $1\frac{1}{4}$-hour marks in Graph 2 B. The difference between the beginning and end results of Graph 1 B. was 2,94-seconds and for Graph 2 B it was 4,15-seconds. Both Graph 1 B and Graph 2 B showed a decline in average reaction time over time.

NUMBER OF ERRORS (GRAPH 2 C, PAGE 119)

Number of errors ranged between 2 at the ½-hour mark and 24 at the 1¾-hour mark with an average of 13 per quarter-hour. The difference between the beginning and end results was 7. There was an increase in the average number of errors over time from 16 at the ¼-hour mark to 23 at the 2-hour mark.

In Graph 1 C the least errors occurred at the 1¼- and the 1¾-hour marks while in Graph 2 C they occurred at the ½-hour mark. The maximum number of errors was found at the ¼ and ½-hour marks in Graph 1 C while at the 1¾-hour mark in Graph 2 C. The difference between the beginning and end results was greater for Graph 2 C with it being 7 errors as opposed to 1 for Graph 1 C. Graph 1 C thus showed a slight decline in the average number of errors over time while Graph 2 C showed a large rise.

PERCENTAGE OF FALSE REPORTS (GRAPH 2 D, PAGE 120)

The percentage of false reports ranged between 2,70% at the 1-hour mark and 61,54% at the ¼-hour mark with an average of 18,81% per quarter-hour as opposed to Graph 1 D's 12,23% The difference between the beginning and end results was 34,51 . Although there was a steady rise from after the 1-hour mark false reports declined over time from 61,54% at the ¼-hour mark to 27,03% at the 2-hour mark.

The highest percentages of false reports occurred at the ¼-hour mark in Graph 1 D and at the ¼-hour mark in Graph 2D; the lowest percentages occurred at the 2-hour mark in Graph 1 D and at the 1-hour mark in Graph 2 D. The difference between beginning

and/...

and end results was less for Graph 1 D with a figure of 14,90% as opposed to Graph 2 D's 34,51%. Both graphs thus showed a decline in the percentage of false reports.

PERCENTAGE OF MISSED SIGNALS (GRAPH 2E, PAGE 121)

The percentage of missed signals ranged between 0,00% at the $\frac{1}{2}$-hour mark and 88,24% at the 1$\frac{3}{4}$-hour mark with an average of 56,64% per quarter-hour as opposed to Graph 1 E's 56,10%. The difference between the beginning and end results was 25,13%. A rise in the percentage of missed signals occurred over time from 61,54% at the $\frac{1}{4}$-hour mark to 86,67% at the 2-hour mark.

The lowest percentages were at the 1$\frac{3}{4}$-hour mark in Graph 1 E and the $\frac{1}{2}$-hour mark in Graph 2E; the highest percentages were at the 1-hour mark in Graph 1 E and the 1$\frac{3}{4}$-hour mark in Graph 2 E. The difference between the beginning and end results was greater for Graph 2 E with it being 25,13% as opposed to 12,28% for Graph 1 E. Thus both graphs showed an increase in the percentage of missed signals over time.

CONCLUSIONS

Graphs 2 A to 2 E showed wider differences between the beginning and end results for all the readings than did graphs 1 A to 1 E. Graph 2 A showed a higher overall number of responses (48,38) per quarter hour than Graph 1 A (38,19) but this was probably the result of the removal of the initial 15-second display of the complex figure.

The/...

The average reaction time per quarter-hour was lower for Graph 2 B (18,77-seconds) than for Graph 1 B (23,80) and was related directly to the greater number of responses as stated above. Graph 1 C's lower average number of errors per ¼-hour could also be attributed to less signals occurring within each ¼-hour period. Graph 2D to 2E showed the following higher results which were in the direction of decrement of performance over time (Table 4):

| | Graph 1 | Graph 2 |
|---|---|---|
| Percentage of False Reports | 12,23 | 18,81 |
| Percentage of Missed Signals | 56,10 | 56,64 |

Table 4. Comparison of Observed Average Scores per ¼-Hour from Graphs 1 and 2.

All the graphs showed a decline in average response time and percentage of false reports, an increase in the number of responses and percentage of missed signals. Graph 1 C however showed a decline in the number of errors while Graph 2 C showed an increase. Graph 2 A to Graph 2 E merely served as indicators of the possible direction of results as the scores reflected on them were those of only 1 subject and so were not representative. These graphs were used to indicate whether the task was now more complex than that reflected in Graph 1 A to Graph 1 E and were used to construct the procedure giving rise to the results reflected in Graph 3 A to Graph 3 E.

The results of the first revised method in Graphs 2 A to 2 E thus show results towards the right direction,

namely/...

namely decrement. It was decided to attempt to accelerate this movement by increasing the task's complexity even more by increasing the number of complex slides randomly presented from 80 to 162. It was hoped that the subjects would now find it more difficult to learn the temporal regularity of simple figures. They would therefore have to attend consistently and not rely upon memory of the sequence of simple figures. In other words, the subject, could no longer disregard the initial period of simple figure presentation. Further, because there was now an increase in the number of complex slides used, the probability with which the simple slides occurred in the complex slides decreased and so possibly raising the possibility of performance decrement. It was hoped that the above aided by the discontinued first presentation of the complex figure, would lead to performance decrement. A third pilot study was conducted for same reasons as the first.

Table 5 Subject Number 3

| Observed Results | | | | | |
|---|---|---|---|---|---|
| Time in Quarter-Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
| $\frac{1}{4}$ | 42 | 21,46 | 16 | 61,54 | 61,54 |
| $\frac{1}{2}$ | 44 | 20,45 | 2 | 18,18 | 0,00 |
| $\frac{3}{4}$ | 43 | 20,93 | 5 | 3,23 | 33,33 |
| 1 | 53 | 16,98 | 15 | 2,70 | 87,50 |
| $1\frac{1}{4}$ | 53 | 16,98 | 12 | 5,45 | 62,50 |
| $1\frac{1}{2}$ | 49 | 18,37 | 7 | 5,88 | 33,33 |
| $1\frac{3}{4}$ | 51 | 17,65 | 24 | 26,47 | 88,24 |
| 2 | 52 | 17,31 | 23 | 27,03 | 86,67 |
| Average Per $\frac{1}{4}$ - Hour | 48,38 | 18,77 | 13 | 18,81 | 56,64 |
| Difference Between Beginning and end Results | 10 | 4,15 | 7 | 34,51 | 25,13 |

FIG 11 GRAPH 2 A FOR TABLE 5

NUMBER OF RESPONSES

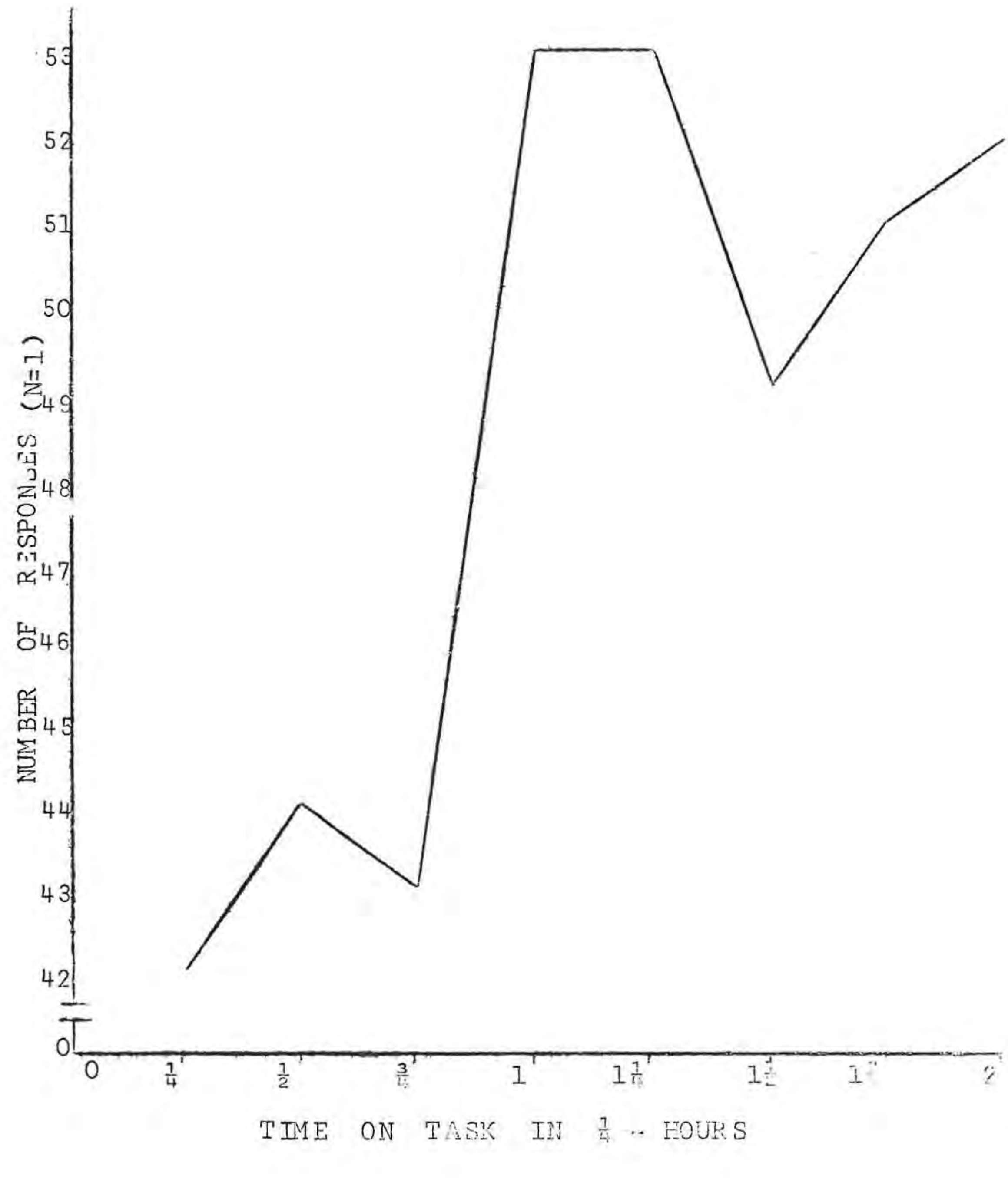
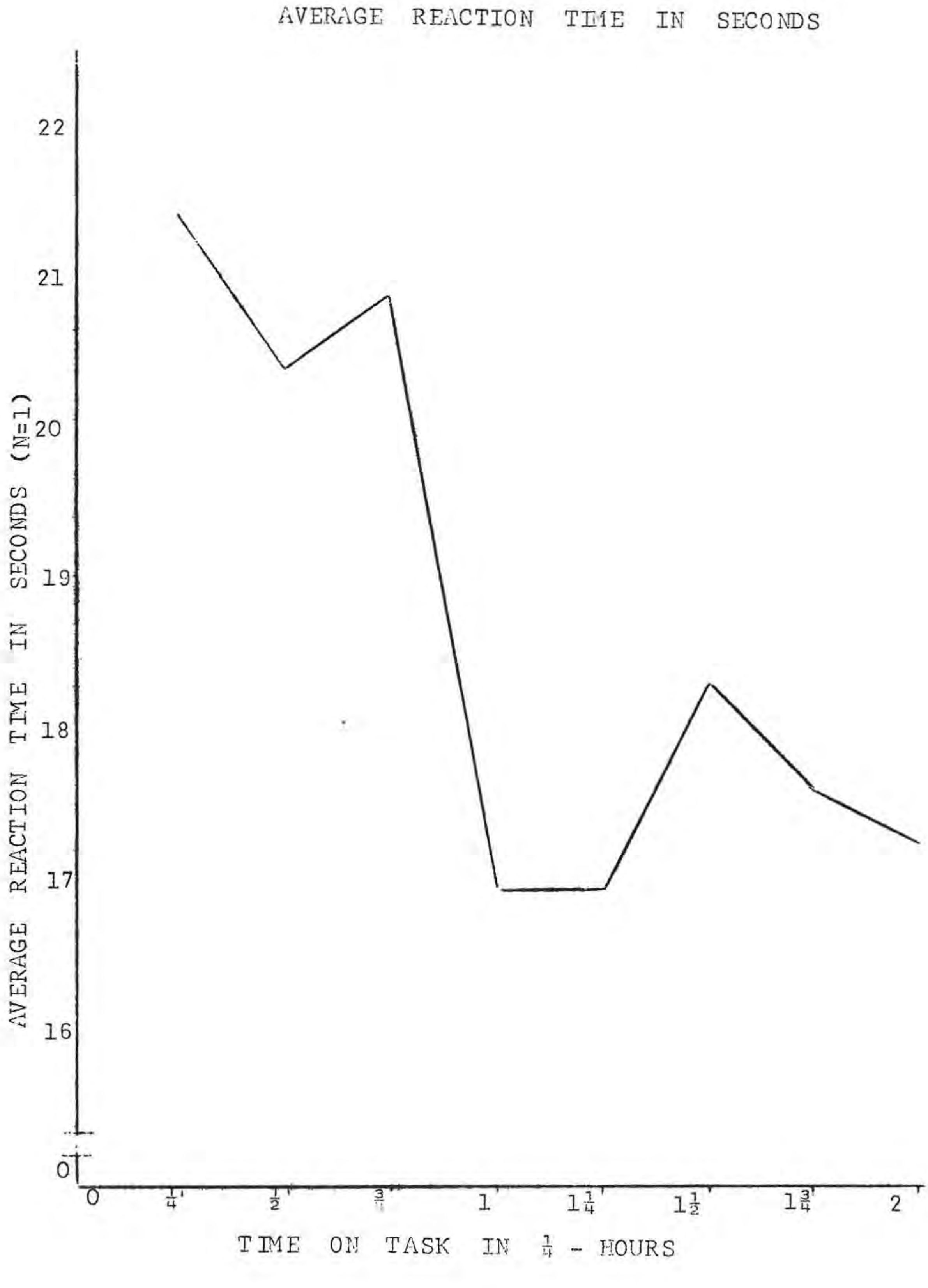


FIG. 11 GRAPH 2 B FOR TABLE 5



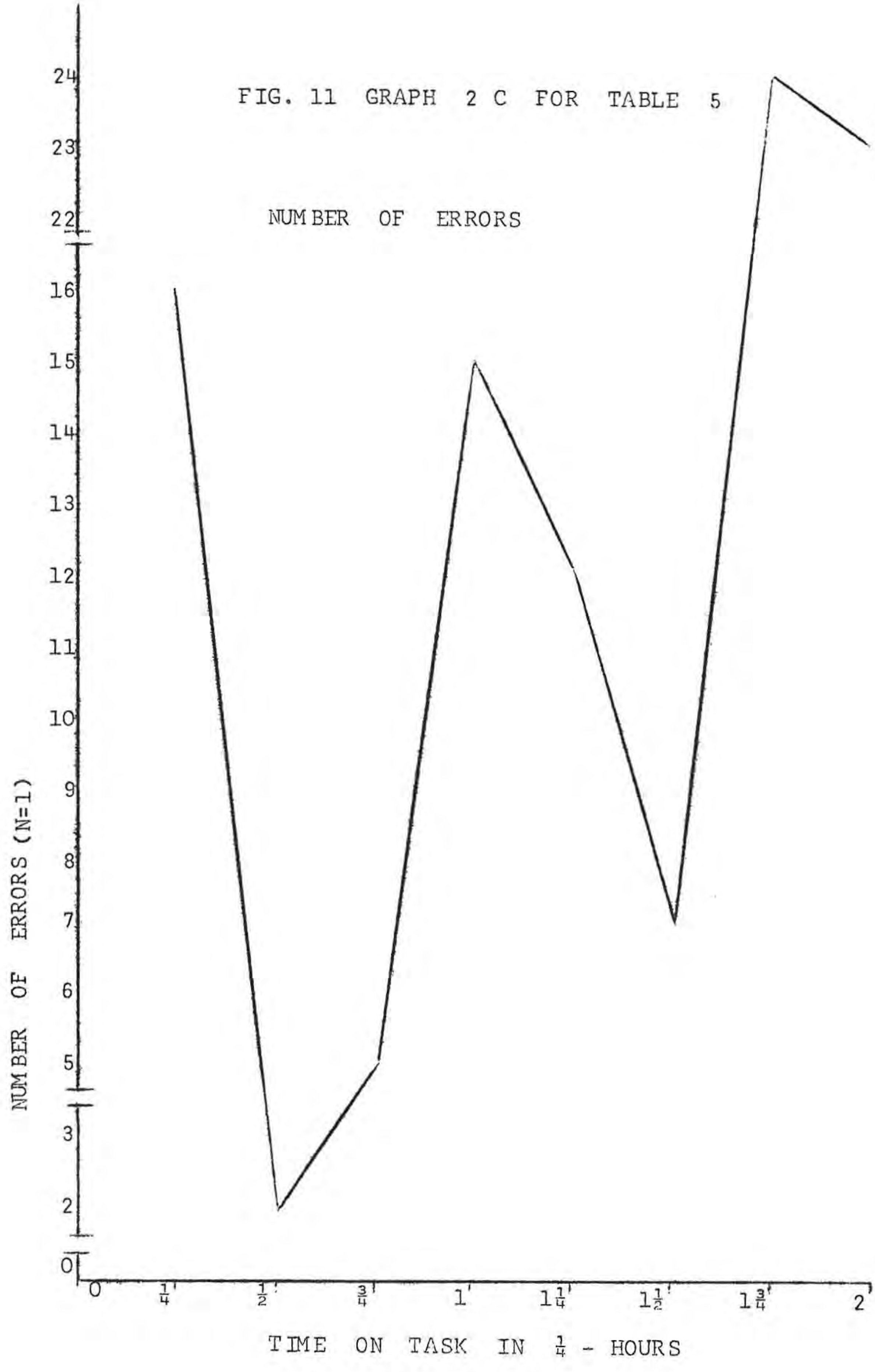



FIG. 11 GRAPH 2 C FOR TABLE 5

FIG. 11 GRAPH 2 D FOR TABLE 5

PERCENTAGE OF FALSE REPORTS

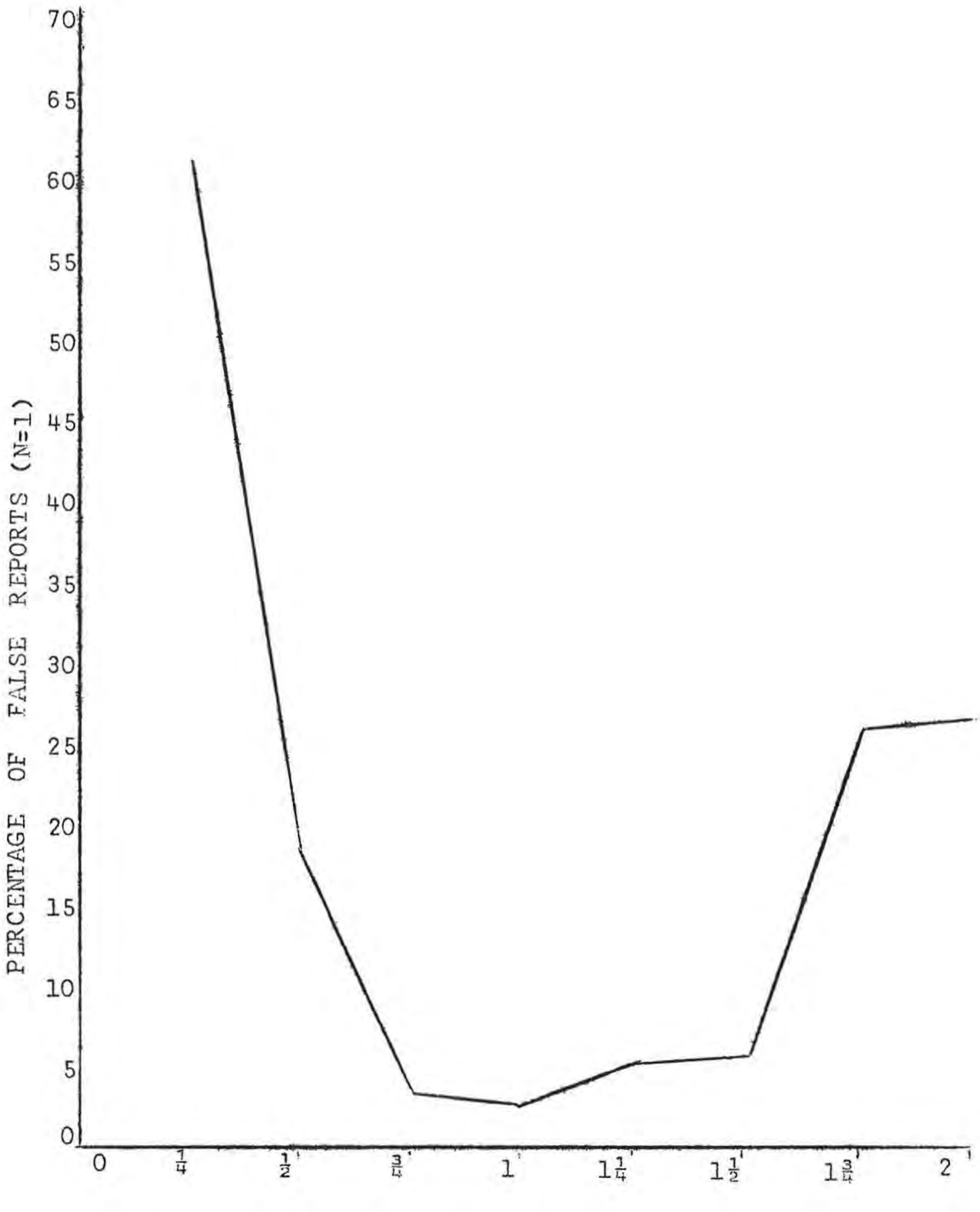
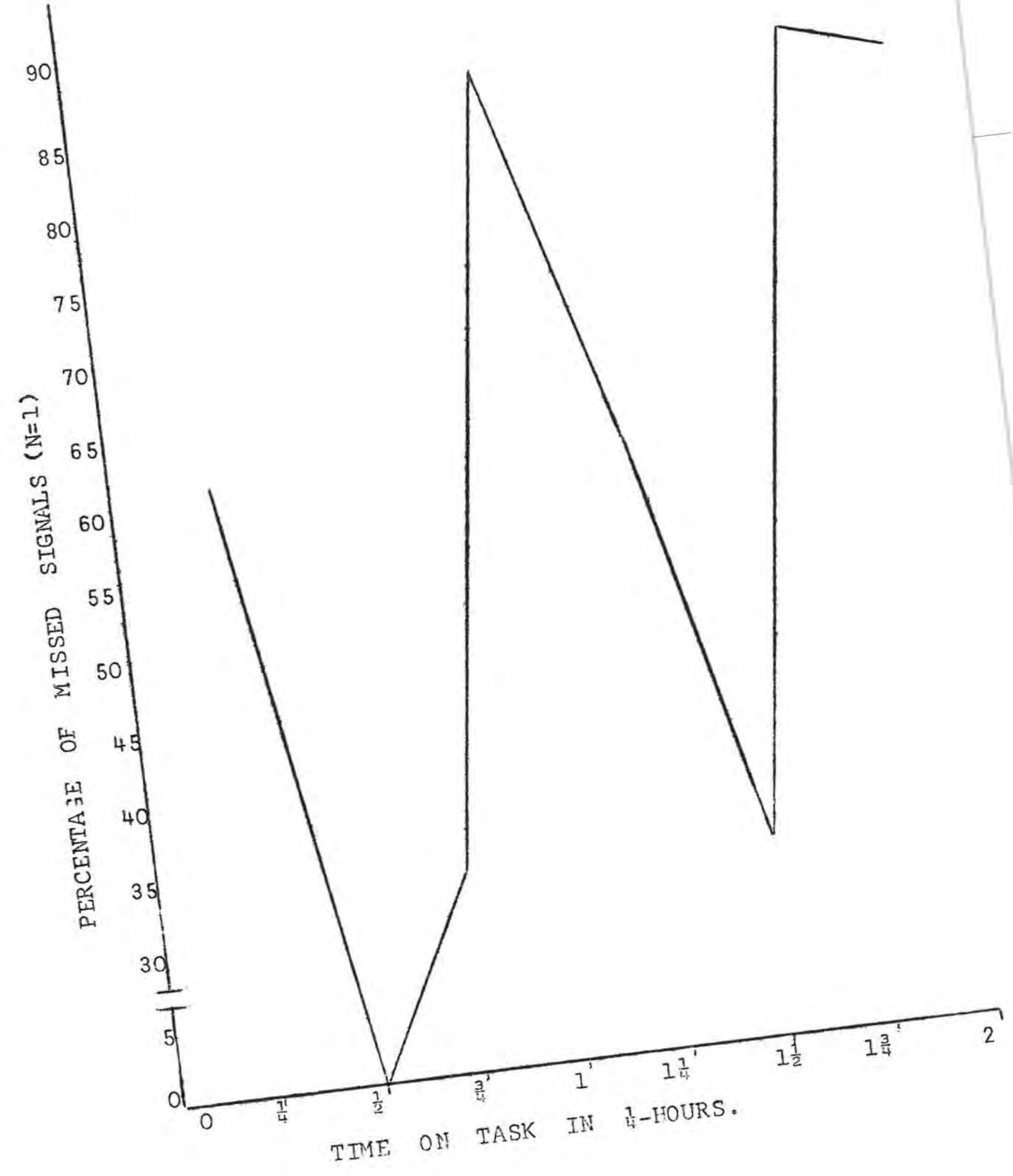


FIG. 11 GRAPH 2 E FOR TABLE 5

PERCENTAGE OF MISSED SIGNALS



# CHAPTER V1

# THIRD PILOT STUDY USING THE SECOND REVISED METHOD

# CHAPTER V1

## THIRD PILOT STUDY USING THE SECOND REVISED METHOD

In the third pilot study changes from the first revised method were in apparatus where the number of slides was increased and so the handling of the slide trays was somewhat modified. Also, a sample of 4 subjects was tested and so the results tabulated and shown on the graphs were the average results of 4 subjects and not just the results of 1 subject as in the second pilót study.

### APPARATUS

2 TWO KODAK CAROUSEL S PROJECTORS

The projector projecting simple test slides used 1 tray filled with 81 simple test slides of 8 simple test patterns in random order. The projector projecting complex slides used 2 slide trays each containing 81 test slides of complex test figures.

The modification to the slide trays necessitated that when the 2 trays of complex slides were interchanged the space on the new tray marked 0, that is, the space for either complex slide number 81 or 162 was left blank. While simple slide number 81 or 162 (the same simple slide) was being projected for 10-seconds by Projector I with complex slide number 81 or 162 respectively positioned for prejection in Projector 11, the tray which contained this appropriate complex slide was removed and the other positioned in its place. Consequently,after the subject's response either complex slide number 81 or 162 slipped up into slot 0 of the new tray and slide 82 or slide 1 respectively was projected next. While complex slide 1 was being projected complex slide 162 was removed from slot 0 and replaced by complex slide 81 according to its numerical position: while complex slide 82 was being projected complex slide 81 was removed from the space marked 0 and replaced by complex slide 162 according to its proper numerical position in the tray.

3 SLIDES

Instead of 8 simple test slides 81 were now used. That is, each simple figure appeared 20 times for 162 complex slides except B, which appeared 22 times as complex slides 81 and 162 were preceded by simple slide B. The extra slides were made the same way as before.

Some/...

Some of them, and some of the original 80 were changed from east to west and north to south to create more new complex figures. [See Table 47 for order of simple and complex figures.] [See Appendix 9 for diagrams of figures.]

## DISCUSSION OF TABLE 12 AND GRAPHS 3A TO 3 E WITH A COMPARISON BETWEEN GRAPHS 1A TO 1E, 2A TO 2E, AND 3A TO 3E

Graphs 1 A to 3 A, 1B to 3 B, and 1 C to 3 C could not be compared regarding average performance per $\frac{1}{4}$-hour for 2-hours as the initial 15-second presentation of the complex figure had been discontinued for Graphs 2 and 3.

### NUMBER OF RESPONSES (GRAPH 3A, PAGE 136)

The number of responses ranged between 37,25 at the $\frac{1}{4}$-hour mark and 44 at the $1\frac{3}{4}$-hour mark with an average of 40,16 responses per quarter-hour. The difference between the beginning and end results was 3,50. There was an increase in the number of responses over time on Graph 3 A from 37,25 responses at the $\frac{1}{4}$-hour mark to 40,75 at the 2-hour mark.

The most responses on Graph 1 A occurred at the $1\frac{3}{4}$-hour mark while they occurred at both the 1 and $1\frac{1}{4}$-hour marks in Graph 2A and at the $1\frac{3}{4}$-hour mark on Graph 3 A. The lowest number of responses occurred at the $\frac{1}{2}$ and $\frac{3}{4}$-hour marks in Graph 1 A, and at the $\frac{1}{4}$-hour marks on Graph 2A and Graph 3A. The difference between the beginning and end results for Graph 1 A was 5, for Graph 2 A was 10 and for Graph 3 A

it/...

it was 3,50. All three graphs showed an increase in the average numberof responses over time. The average was 48,38 per $\frac{1}{4}$-hour for 2-hours for Graph 2 A followed by Graph 3 A with 40,16. The decline in responses in Graph 3A as opposed to Graph 2 A possibly indicated an increase in difficulty.

AVERAGE REACTION TIME IN SECONDS (GRAPH 3B, PAGE 137)

The average reaction time in seconds ranged between 22,31 at the $1\frac{3}{4}$-hour mark and 26,36-seconds at the $\frac{3}{4}$-hour mark with an average of 24,39-seconds per quarter-hour. The difference between the beginning and end results was 1,72-seconds. There was a slight decline in average reaction time over time on Graph 3 B from 25,44-seconds at the $\frac{1}{4}$-hour mark to 23,72-seconds at the 2-hour mark.

The highest average reaction time per $\frac{1}{4}$-hour in Graph 1 B was at $\frac{3}{4}$ of an hour and at the $\frac{1}{2}$-hour mark in Graph 2B; in Graph 3B it occurred at $\frac{3}{4}$ of an hour. The lowest average reaction was at the $1\frac{3}{4}$ of an hour mark in Graph 1 B, at 1 and $1\frac{1}{4}$-hours in Graph 2 B, and at $1\frac{3}{4}$-hours in Graph 3 B. Graphs 1 B, 2 B, and 3 B all showed a decline in average reaction time over time. The difference between the beginning and end results were fairly close in all 3 Graphs: it being 2,94 in Graph 1 B, 4,15 in Graph 2 B and 1,72-seconds in Graph 3 B. The average reaction time per $\frac{1}{4}$-hour for 2-hours of 24,39-seconds for Graph 3 B was longer than Graph 2 B's 18,77-seconds,

thus/...

thus indicating that the present task was now possibly more complex as the subjects were taking longer to respond.

NUMBER OF ERRORS (GRAPH 3 C, PAGE 138)

The number of errors ranged between 8 at the $\frac{3}{4}$-hour mark and 12,75 at the $\frac{1}{4}$-hour mark with an average of 10,06 per quarter hour. The difference between the beginning and end results was 1,25. The number of errors declined from 12,75 at the $\frac{1}{4}$-hour mark to 11,50 at the 2-hour mark.

In Graph 1 C the least errors occurred at the $1\frac{1}{4}$- and $1\frac{3}{4}$-hour marks, in Graph 2 C they occurred at the $\frac{1}{2}$ -hour mark while in Graph 3 C they occurred at the $\frac{3}{4}$-hour mark. The maximum number of errors occurred in Graph 1 C at the $\frac{1}{4}$ of an hour mark, in Graph 2 C at the $1\frac{3}{4}$-hour mark while at the $\frac{1}{4}$-hour mark in Graph 3 C. Graphs 1 C and 3 C showed only a slight decline in the number of errors over time while Graph 2 C showed a rise. The difference between the beginning and end results was 7 errors and so greatest for Graph 2 C followed by Graph 3 C with 1,25 errors and by Graph 1 C with 1 error. The average number of errors per $\frac{1}{4}$-hour for 2-hours was 13 for Graph 2 C, and 10,06 for Graph 3 C. Though Graph 2 C showed a higher number of errors than Graph 3 C it was not a reliable score as this graph only reflected the results of 1 subject. Further, the task's repetitive nature with the same order of

sequence/...

sequence of 8 simple figures made the task less complex than that reflected on Graph 3 C but more complex than that on Graph 1 C as the initial 15-second presentation of the complex figure had been discontinued.

PERCENTAGE OF FALSE REPORTS (GRAPH 3 D, PAGE 139)

The percentage of false reports ranged between 13,99% at the $\frac{3}{4}$-hour mark and 32,20% at the $\frac{1}{4}$-hour mark with an average of 21,45% per quarter-hour. The difference between the beginning and end results was 10,86%. There was a slight decline in the percentage of false reports from 32,20% at the $\frac{1}{4}$-hour mark to 21,34% at the 2-hour mark.

The highest percentages occurred at the $\frac{1}{2}$-hour mark in Graph 1 D and at the $\frac{1}{4}$-hour mark in Graph 2 D and Graph 3 D: the lowest percentages occurred at the 2-hour mark in Graph 1 D ,at the 1-hour mark in Graph 2 D ,and at the $\frac{3}{4}$-hour mark in Graph 3 D. All graphs showed a decline in the percentage of false detections over time with Graph 2 D showing the most difference between beginning and end results with a figure of 34,51%; Graph 1 D followed with 14,90% and Graph 3 D showed the least decline with 10,86% The average percentages of false reports per $\frac{1}{4}$-hour for 2-hours were 18,81% for Graph 2D, 12,23% for Graph 1 D, and 21,45% for Graph 3 D.

PERCENTAGE OF MISSED SIGNALS (GRAPH 3 E, PAGE 140)

The percentage of missed signals ranged

between/...

between 50% at the $1\frac{1}{4}$-hour mark and 69,76% at the 2-hour mark with an average of 58,20% per quarter-hour. The difference between the beginning and the end results was 14,29%. There was an increase in the percentage of missed signals over time on Graph 3 E from 55,47% at the $\frac{1}{4}$-hour mark to 69,76% at the 2-hour mark.

The lowest percentages occurred at the $1\frac{3}{4}$-hour mark in Graph 1 E, the $\frac{1}{2}$-hour mark in Graph 2 E, and the $1\frac{1}{4}$-hour mark in Graph 3 E: the highest percentages were at the 1-hour mark in Graph 1 E, the $1\frac{3}{4}$-hour mark in Graph 2 E, and the 2-hour mark in Graph 3 E. All 3 Graphs showed a rise in the percentage of missed signals over time with Graph 2 E showing the greatest rise with a difference of 25,13% between beginning and end results; Graph 3 E followed with a difference of 14,29% and Graph 1 E showed the least difference with a reading of 12,28%. The average percentage of missed signals per $\frac{1}{4}$-hour for 2-hours was 58,20% for Graph 3 E, 56,64% for Graph 2 E, and 56,10% for Graph 1 E.

The results thus tended towards the right direction, namely performance decrement.

## CONCLUSIONS

Data gave no evidence that repeating the 162 slides facilitated performance on the repeated slides.

Graph 3 B's increase in average response time per $\frac{1}{4}$-hour for 2-hours with time on the task over Graph 2 B

indicated/...

indicated an increase in difficulty and decrement of performance; Graph 1 B could not be compared here due to the additional time taken in the 15-second preview of the complex figures which cut down on time, which, in Graph's 2 B and 3 B, had been spent on responding to additional figures. The same reasoning could be applied to the least number of responses occurring in Graph 1 A. The decline in number of responses over time in Graph 3 A as opposed to Graph 2 A once again possibly indicated an increase in difficulty and decrement in Graph 3A. Similarly, the least average number of errors per ¼-hour for 2-hours occuring in Graph 1 C (9,31) could also be attributed to this initial 15 - second presentation of the complex slide. The highest reading was for Graph 2 C (13) while for Graph 3 C it was 10,06.

It must be remembered that Graph 2's results were not representative and only served as a tentative indicator of the direction of results. The direct comparison was therefore between Graphs1 and 3. Graph 3 has shown greater performance decline over time than Graph 1 as illustrated in the following table (Table 6) where Graph 3 showed a greater decrement in the number of errors and in the percentage of missed signals, and a lesser improvement in the percentage of false reports.

Once again the task likely to show greater consistent decrement over time was that represented in Graph 3 where all averages were highest.

| Difference Between Beginning and End Results | Graph 1 | Graph 3 | Decrement in Graphs | |
|---|---|---|---|---|
| | | | 1 | 3 |
| Number of Errors | 1 | 1,25 | | |
| Percentage of False Reports | 16,90 | 10,86 | | |
| Percentage of Missed Signals | 12,28 | 14,29 | Yes | Yes |

TABLE 6 Difference Between the Average Observed Scores at the $\frac{1}{4}$ and 2-Hour Marks on Graphs 1 and 3.

On the face of it therefore, Graph 3's method is more likely to produce decrement.

Another useful table is the one below (Table 7) showing the average performance per $\frac{1}{4}$-hour for 2-hours on the percentages of false reports and missed signals for Graphs 1 and 3.

| Average Performance per $\frac{1}{4}$-Hour | Graph 1 | Graph 3 |
|---|---|---|
| Percentage of False Reports | 12,23 | 21,45 |
| Percentage of Missed Signals | 56,10 | 58,20 |

TABLE 7 Observed Overall Averages per $\frac{1}{4}$-Hour on Graphs 1 and 3.

Graphs 3 A to 3 E with the second revised method have not yielded results as widely different from Graphs 1 A to 1 E as indicated by Graphs 2 A to 2 E. What might have had an effect was that 2 subjects were used in the sample for Graphs 1 A to 1 E while 4 subjects were used in the sample for Graphs 3 A to 3 E. It was decided however to continue experimentation with the second revised method to ascertain whether performance decrement over time in fact occurred in a task of the present nature. In addition to the 4 subjects in the third pilot study, a further 26 subjects were used, bringing the total to 30 subjects.

Table 8 Subject Number 4

| Time in Quarter-Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of false Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 30,00 | 30,00 | 12,00 | 34,62 | 75,00 |
| $\frac{1}{2}$ | 31,00 | 29,03 | 13,00 | 35,71 | 100,00 |
| $\frac{3}{4}$ | 26,00 | 34,62 | 9,00 | 30,43 | 66,67 |
| 1 | 22,00 | 40,91 | 7,00 | 29,41 | 50,00 |
| $1\frac{1}{4}$ | 25,00 | 36,00 | 5,00 | 22,73 | 0,00 |
| $1\frac{1}{2}$ | 26,00 | 34,62 | 12,00 | 33,33 | 100,00 |
| $1\frac{3}{4}$ | 26,00 | 34,62 | 12,00 | 62,50 | 66,67 |
| 2 | 27,00 | 33,33 | 7,00 | 21,74 | 50,00 |

Table 9 Subject Number 5

| Time in Quarter-Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of false Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 29,00 | 31,03 | 9,00 | 28,00 | 50,00 |
| $\frac{1}{2}$ | 38,00 | 23,68 | 2,00 | 1,43 | 0,00 |
| $\frac{3}{4}$ | 41,00 | 21,95 | 8,00 | 9,38 | 55,56 |
| 1 | 38,00 | 23,68 | 10,00 | 24,24 | 40,00 |
| $1\frac{1}{4}$ | 34,00 | 26,47 | 14,00 | 28,57 | 100,00 |
| $1\frac{1}{2}$ | 36,00 | 25,00 | 5,00 | 11,43 | 50,00 |
| $1\frac{3}{4}$ | 44,00 | 20,45 | 14,00 | 27,03 | 57,14 |
| 2 | 35,00 | 25,71 | 14,00 | 32,14 | 71,43 |

Table 10 Subject Number 6

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 51,00 | 17,65 | 12,00 | 20,45 | 46,86 |
| ½ | 58,00 | 15,52 | 10,00 | 6,00 | 87,50 |
| ¾ | 58,00 | 15,52 | 12,00 | 8,16 | 88,89 |
| 1 | 56,00 | 16,07 | 13,00 | 14,00 | 100,00 |
| 1¼ | 55,00 | 16,36 | 9,00 | 6,37 | 75,00 |
| 1½ | 58,00 | 15,52 | 10,00 | 4,00 | 100,00 |
| 1¾ | 57,00 | 15,79 | 13,00 | 13,13 | 100,00 |
| 2 | 54,00 | 16,67 | 10,00 | 4,65 | 90,92 |

Table 11 Subject Number 7

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 39,00 | 23,08 | 18,00 | 45,71 | 50,00 |
| ½ | 38,00 | 23,63 | 8,00 | 20,59 | 25,00 |
| ¾ | 27,00 | 33,33 | 3,00 | 8,00 | 12,50 |
| 1 | 39,00 | 23,08 | 6,00 | 14,76 | 14,29 |
| 1¼ | 45,00 | 20,00 | 12,00 | 24,44 | 25,00 |
| 1½ | 46,00 | 19,57 | 10,00 | 21,43 | 25,00 |
| 1¾ | 49,00 | 18,37 | 8,00 | 15,00 | 22,22 |
| 2 | 47,00 | 19,15 | 15,00 | 26,83 | 66,67 |

Table 12 Average observed results of subjects numbered 4,5,6,7.

AVERAGE OBSERVED RESULTS

| Time in Quarter - Hour Divisions | Average Number of Responses | Mean of The Average Reaction Time in Seconds | Average Number of Errors | Average Percentage of False Reports | Average Percentage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 37,25 | 25,44 | 12,75 | 32,20 | 55,47 |
| ½ | 41,,25 | 22,97 | 8,25 | 15,93 | 53,13 |
| ¾ | 38,00 | 26,36 | 8,00 | 13,99 | 55,91 |
| 1 | 38,75 | 25,94 | 9,00 | 20,60 | 51,07 |
| 1¼ | 39,75 | 24,71 | 10,00 | 20,53 | 50,00 |
| 1½ | 41,50 | 23,68 | 9,25 | 17,55 | 68,75 |
| 1¾ | 44,00 | 22,31 | 11,75 | 29,42 | 61,51 |
| 2 | 40,75 | 23,72 | 11,50 | 21,34 | 69,76 |
| Average per ¼ - Hour | 40,16 | 24,39 | 10,06 | 21,45 | 58,20 |
| Difference Between Beginning and End Results | 3,50 | 1,72 | 1,25 | 10,86 | 14,29 |

FIG. 12 GRAPH 3 A FOR TABLE 12

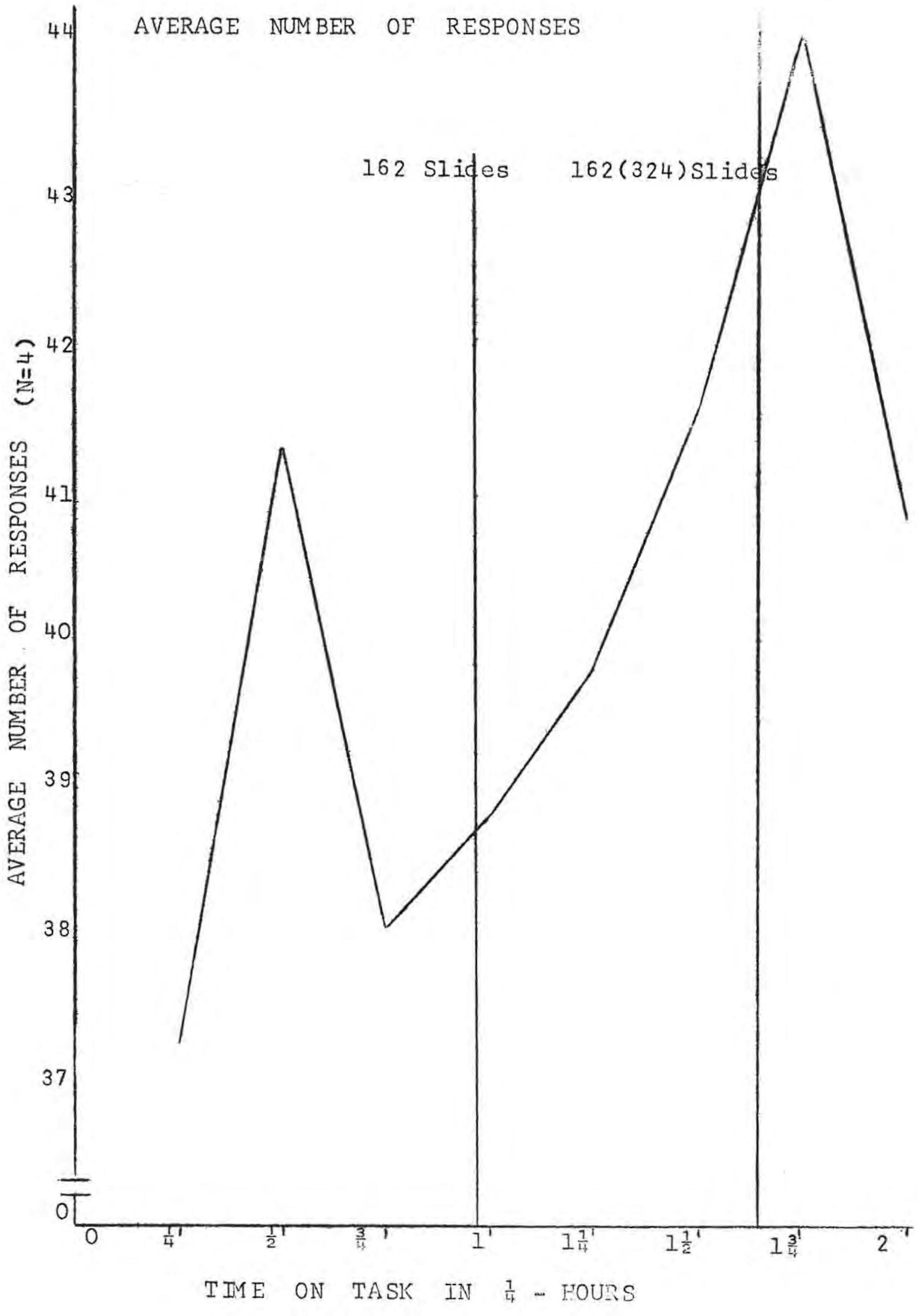


FIG. 12 GRAPH 3 B FOR TABLE 12

AVERAGE REACTION TIME IN SECONDS

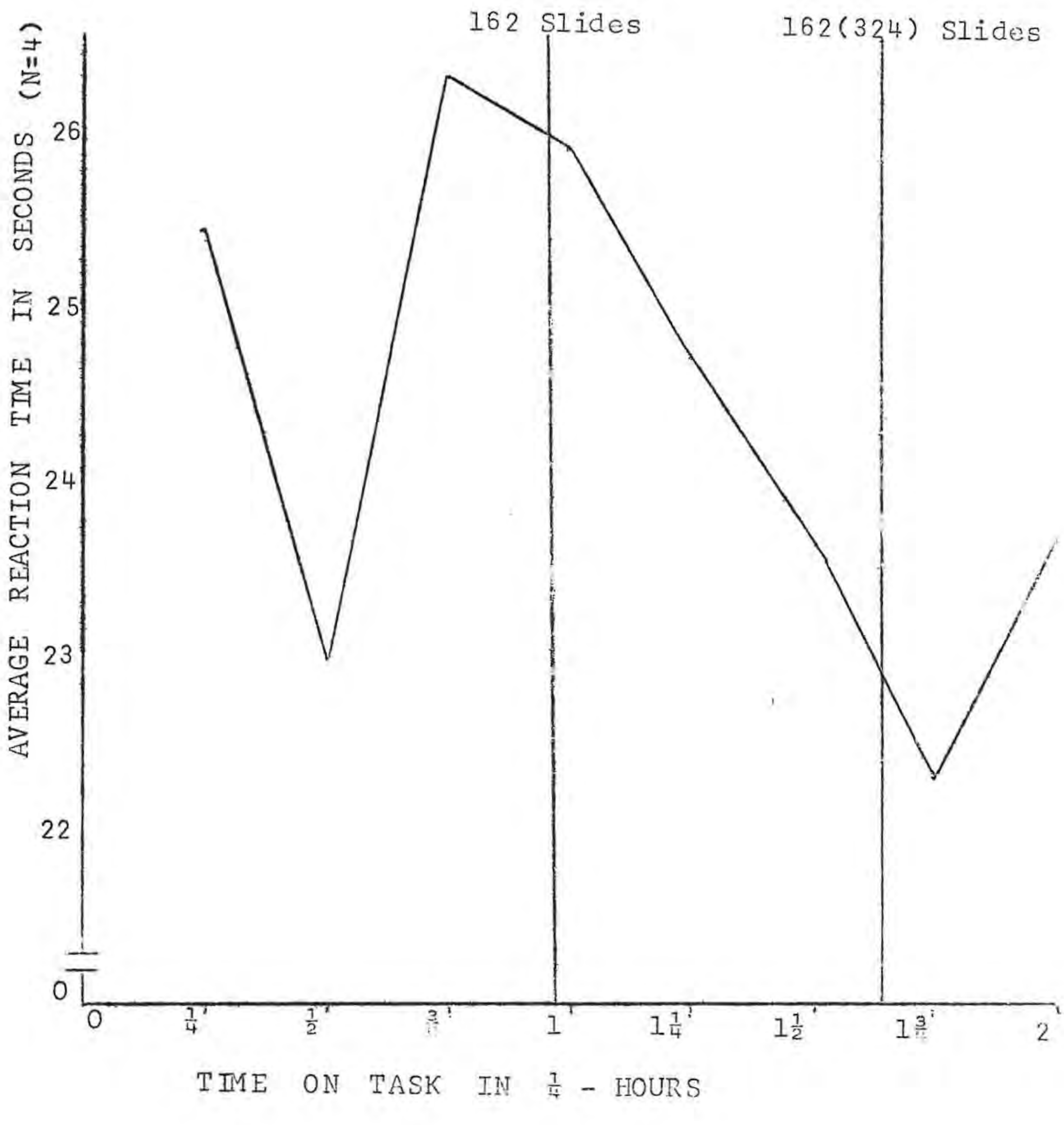


FIG. 12 GRAPH 3 C FOR TABLE 12

AVERAGE NUMBER OF ERRORS

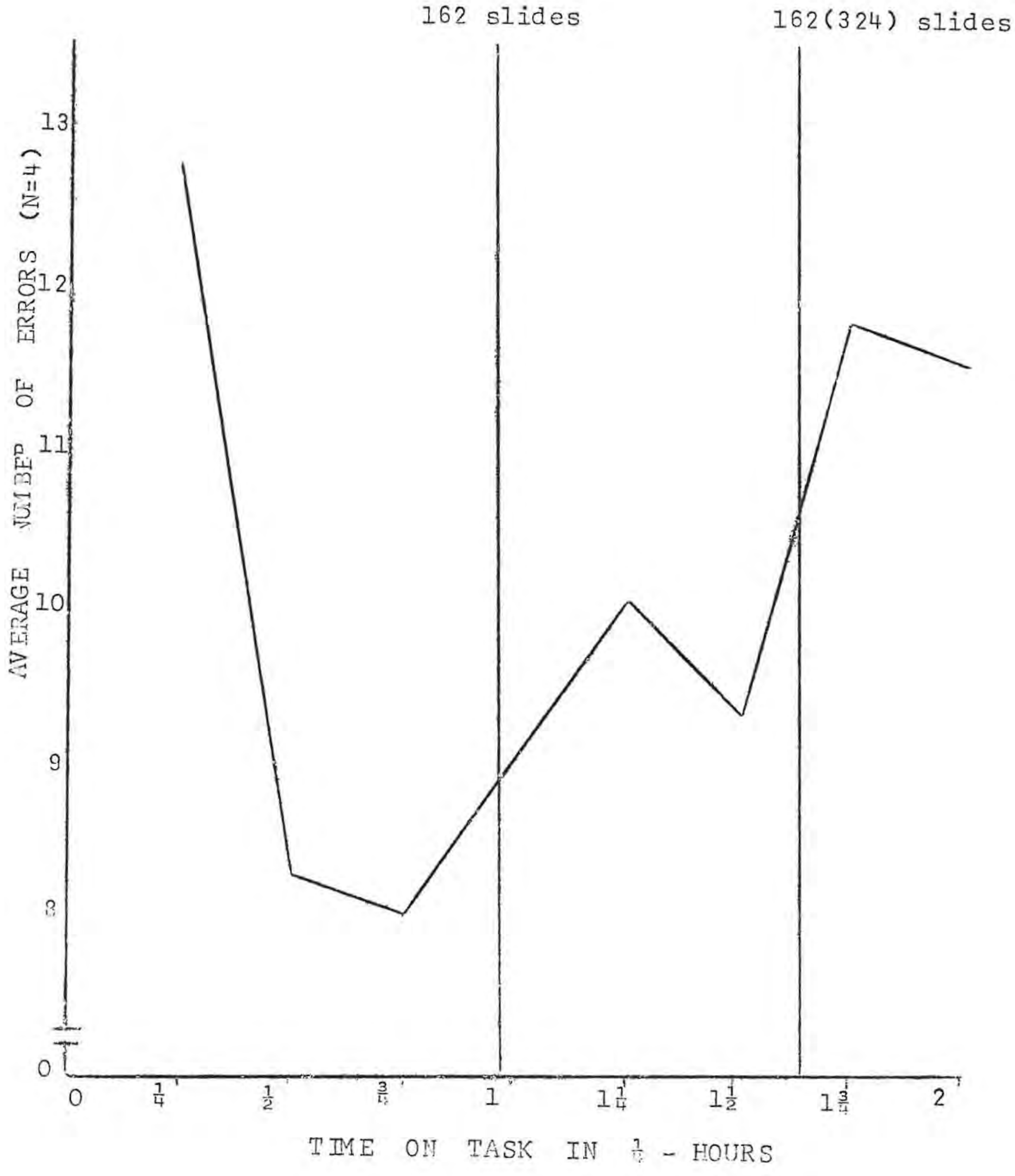
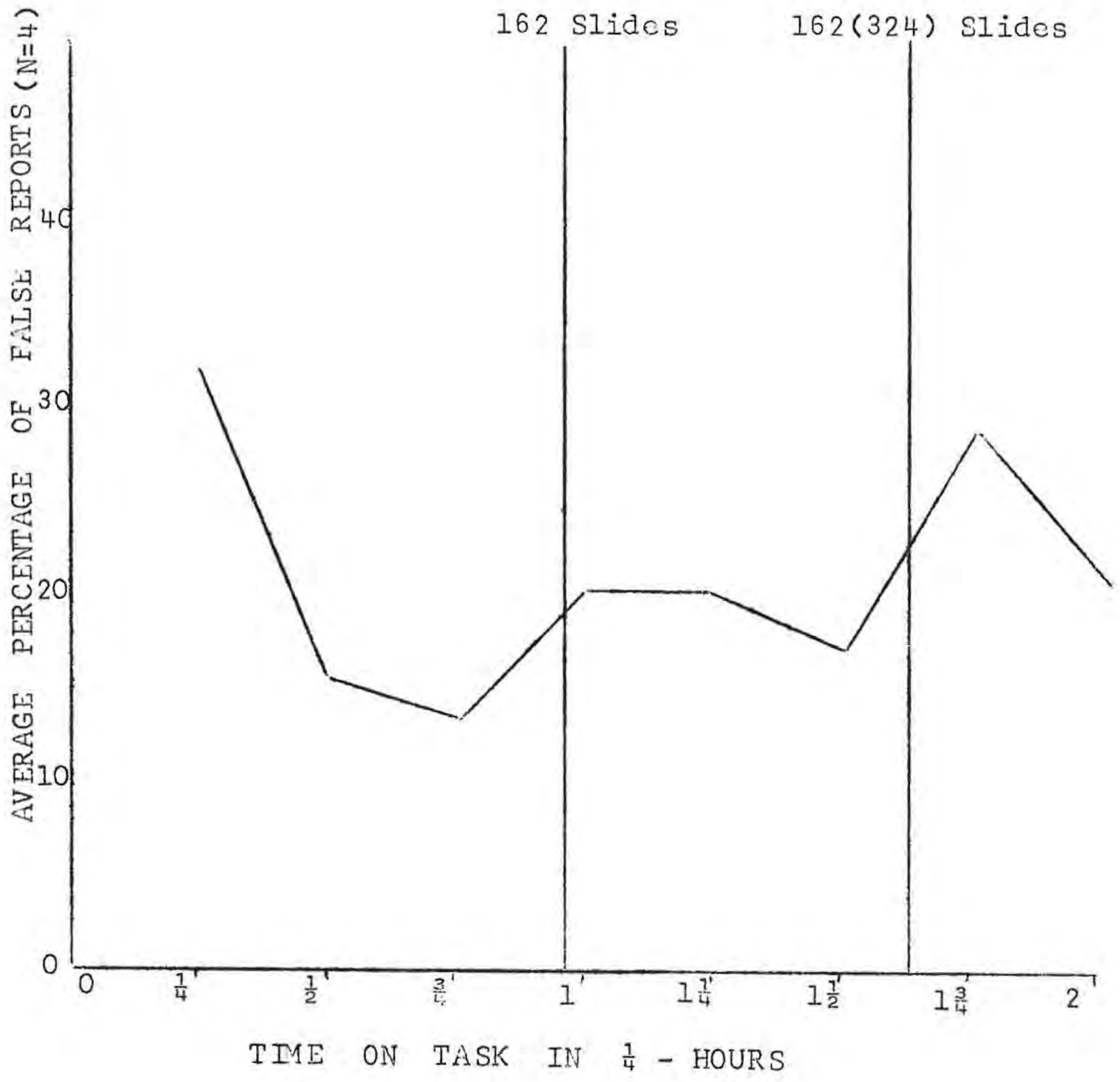


FIG. 12 GRAPH 3 D FOR TABLE 12

AVERAGE PERCENTAGE OF FALSE REPORTS



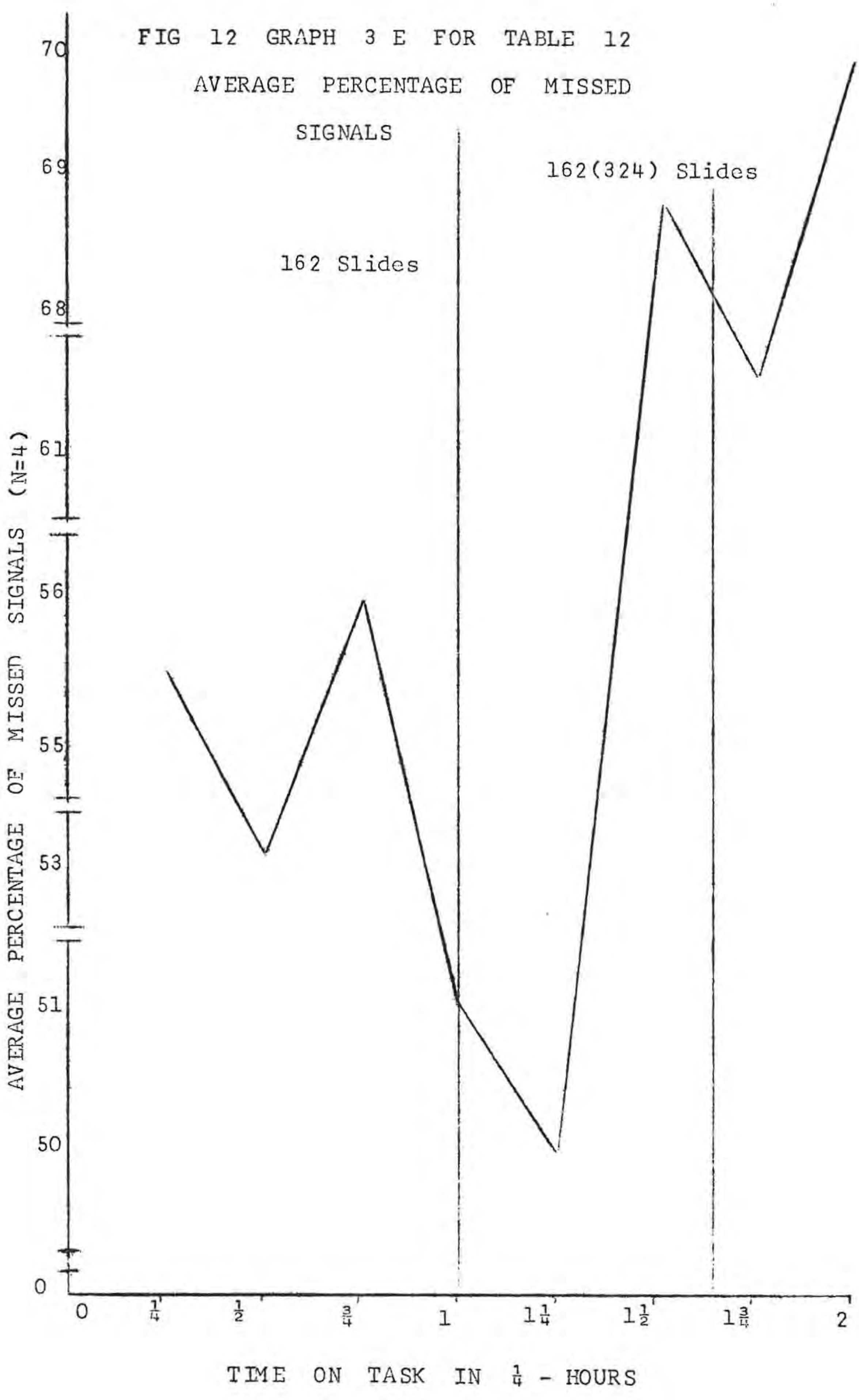



FIG 12 GRAPH 3 E FOR TABLE 12
AVERAGE PERCENTAGE OF MISSED SIGNALS

# CHAPTER V11

## METHOD

# CHAPTER V11

## METHOD

This chapter will outline how the present study was finally undertaken.

APPARATUS

1. BRS 300 and two 24 VDC Power Supplies.
2. Two Kodak Carousel S Projectors with 100 mm lenses to project slides.
3. Five slide trays containing slides of simple and complex geometric figures.
4. Projection Screen.
5. Three-Pen Recorder, 2 Labelled Response Switches.
6. White Noise Generator and a pair of Earphones.
7. Test and Control Rooms.

1. BRS 300 AND TWO 24 VDC POWER SUPPLIES

The BRS 300 Series Digibits offer plug-in logic modules with solid-state circuitry. These modules can be assembled into networks with pluggable patch cords by converting the presentations of logic functions to an operative system. All input and output connections are made at jacks

on/...

on the front panel. All power connections are automatically made when the elements are plugged in.

The BRS 300 (Fig.13) was programmed to co-ordinate the operation of the Three-Pen Recorder, the projection of slides by the two Kodak Carousel S Projectors with 100 mm lenses, and 2 timers and latching relays (Fig.14). This produced the following sequence. Projector number I projected a slide of a simple figure for 10-seconds. This was followed by Projector number II's projection of a complex figure until the subject responded by closing either of the 2 response switches or for 3 - minutes if he did not respond.

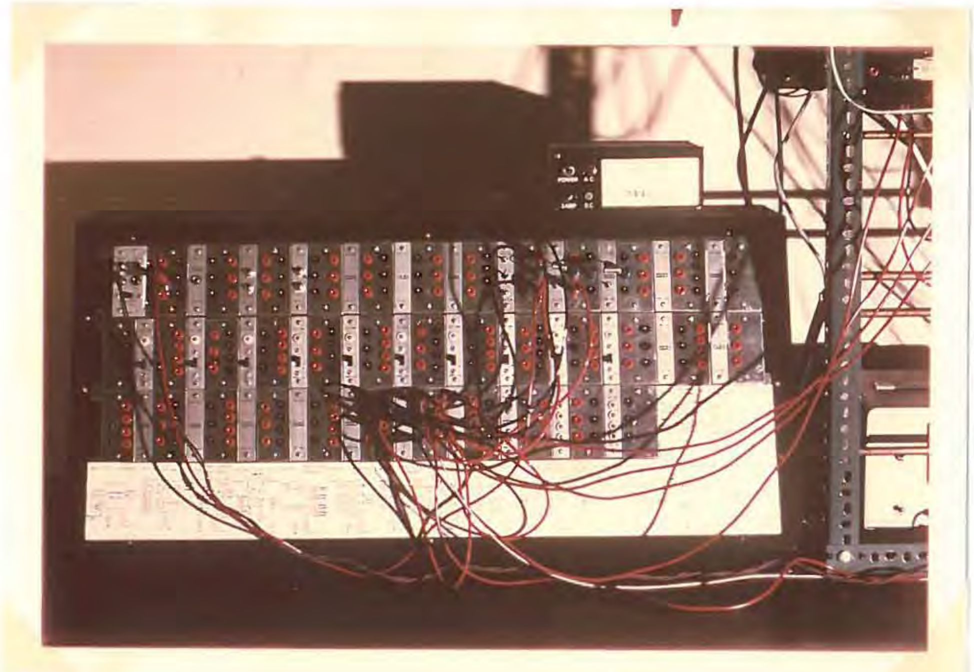


Fig. 13. The BRS 300.

This was also the signal to initiate the display of the next sequence of 2 slides (simple, complex). The BRS 300 also/...

also controlled the 3 pens of the Recorder on which the time sequence of the various operations was recorded. This procedure continued for 2-hours without interruption. [See Appendix 3 for a detailed description of circuitry.]

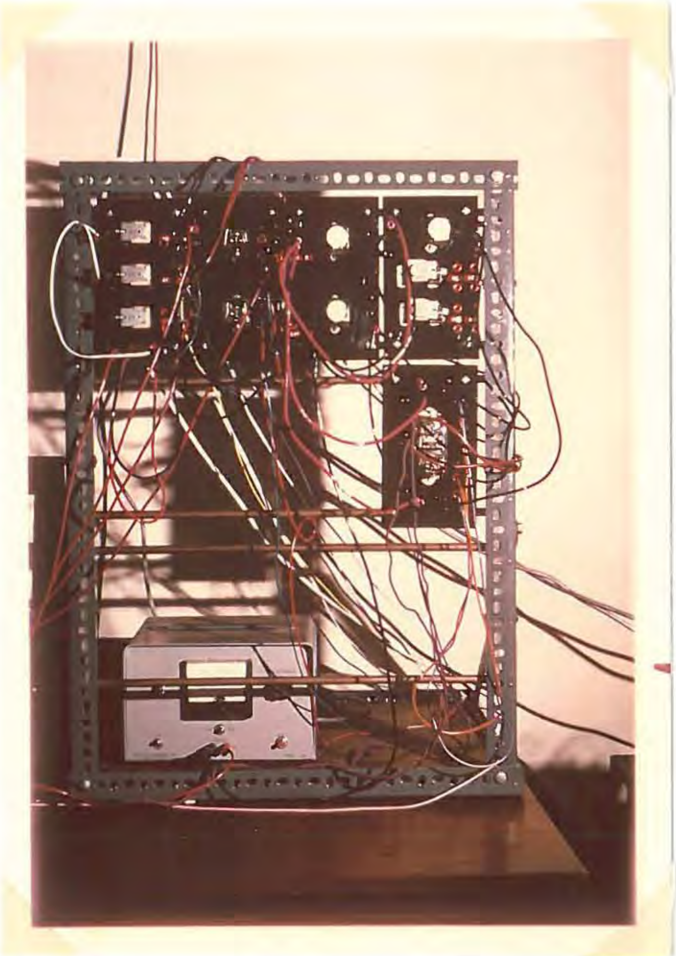


Fig. 14. 24 VDC Power Supply, Timers and Latching Relays.

2. TWO KODAK CAROUSEL S PROJECTORS

Each circular slide tray of the Kodak Carousel S Projectors was constructed to accommodate 80 slides.

The/...

The transparent covers protected the slides against dust and damage when not testing.

Each projector was operated and timed by the BRS 300 through remote control cables fitted to the projectors.

The projector projecting simple slides was allocated 2 slide trays while the one projecting complex slides was allocated 3 trays. The 3 trays of test slides required the modification discussed below. One of the 2 trays containing simple slides contained one simple practice slide. For the first practice trial the first practice simple figure was inserted in slot 1 for the first presentation. During the presentation of the complex figure the simple figure was moved to slot 2 for the second presentation. After the second practice trial this tray and the tray of 2 practice complex slides were removed and replaced respectively by a tray of simple test slides and the first of the 2 trays of complex test slides. The second tray of complex test slides was inserted when the slides in the first had all been projected, the first tray in turn replaced the second and so on.

The 3 trays containing the test slides were each given an extra slot by cutting away the covering of slot number 0. This enabled continuous slide presentation. The projector projecting simple test slides used 1 tray fitted with 81 simple test slides of 8 simple test patterns in random order. The projector projecting complex slides used 2 slide trays each containing 81 test slides of complex test figures.

The modification to the slide trays necessitated that when the 2 trays of complex slides were interchanged the space marked 0 on the new tray,that is, the space for either complex slide number 81 or 162, was left blank in the new tray. While simple slide number 81 or 162 (the same simple slide) was being projected for 10-seconds by Projector I with complex slide number 81 or 162 respectively positioned for projection in Projector II, the tray which contained this appropriate complex slide was removed and the other positioned in its place. Consequently, after the subject's response,either complex slide number 81 or 162 slipped up into slot 0 of the new tray and slide 82 or slide 1 respectively was projected next. While complex slide 1 was being projected complex slide 162 was removed from slot 0 and replaced by complex slide 81 according to its numerical position; while complex slide 82 was being projected complex slide 81 was removed from the space marked 0 and replaced by complex slide 162 according to its proper numberical position in the tray.

The 2 projectors were mounted on a stand one above the other in the control room and projected from positions above head level of a seated subject. Further, each successively projected images through a hatch onto the centre of the screen in the test room (Fig. 2).

3. SLIDES

Slides of simple and complex geometric figures were made in the following way :

In/...

In Witkin's (1950) collection of figures each complex geometrical figure had its simple geometrical figure incorporated into its patterns so that the outline of the simple figure may form part of the boundaries of several subpatterns in the complex figure. The present series however included Witkin's complex figures (e.g. Fig. 3b) which were the critical signals as well as similar figures into which the appropriate simple figures (e.g. Fig. 3a) could not be fitted. This was because one or more of the boundary lines of the simple figures had been omitted and other straight and wavy lines had been added (e.g. Fig.3c). The wavy lines, to indicate colour in Witkin's (1950) straight line drawings, were kept to vary the stimuli by adding not only to the number of lines but also to the kinds of lines. The changing of some of the original 80 figures from east to west and north to south also served to make new complex figures. These additional slides provided the non-critical component of the vigilance task. For the present study figures were drawn in black ink on white paper in sizes relative to Witkin's (1950) figures but magnified. These,when projected, were 12 times bigger than Witkin's. The present practice task consisted of Witkin's practice simple figure with 2 practice complex figures, the practice simple figure being incorporated only into Witkin's original practice complex figure. The test consisted of Witkin's 8 simple designs on 81 slides of simple figures and 162 complex figures consisting of Witkin's original 24 complex test figures and the additional similar ones.

Only/...

Only in Witkin's original 24 complex test figures were simple figures incorporated. Each simple figure appeared 20 times for the 162 complex slides used except B, which appeared 22 times, as complex slides 81 and 162 were preceded by simple slide B.

These practice and test figures were photographed in the following way:

The mid-point between the readings of a light - meter for black and white paper was taken as the *f* stop for the camera. This was *f* 5,6. At a distance of 1,9 feet vertically above the figures, using black and white film of 400 ASA with the camera set at the above *f* stop, the figures were photographed in diffuse sunlight with a shutter speed of $\frac{1}{125}$ second. Each spool of film was then developed for 12-minutes using Kodak D-76 developer, washed in a stopbath of 3% acetic acid, fixed for 4-minutes in Amfix, washed in water for 10-minutes to clean, allowed to dry, and then cut into slides. These slides, when projected onto a screen, were white outlines against a uniformly black background as compared to Witkins coloured designs.

The notation of the simple test designs was A,B,C, D,E,F, and G. The notation of, for example, complex slide F 1 meant that simple figure F was present in complex figure F 1 while in D 2a for example, simple figure D was not present as it was present in D 2 and so on. [For the order of simple and complex figures see Table 47.] [For the designs of simple and complex figures see Appendix 9.]

4. PROJECTION SCREEN

A projection screen was installed in the test room which was darkened during testing. The subject was seated facing the screen with his back to the projectors projecting through on interleading hatch between the control and the test rooms.

5. THREE-PEN RECORDER AND LABELLED RESPONSE SWITCHES.

Two response switches lay on a table before the subject (Fig. 5). Switch 1 activated Pen 2 and Switch 2 activated Pen 3 of the Three-Pen Recorder (Fig. 4) which was driven by the second 24 VDC Power Supply. Switch 1 was depressed if the subject saw the simple figure in the complex figure, Switch 2 was depressed if the subject wished to indicate that the simple figure was not present in the complex figure. Pen 2 was used to indicate speed of response to the presence of the simple figure while Pen 3 was used to indicate speed of response to its absence, whether response was correct or incorrect: Pen 1 of the Three-Pen Recorder recorded every time a new complex slide was flashed onto the screen, that is, either after the pressing of Switch 1 or Switch 2 or after the timing out of 3-minutes when the subject was unable to indicate the presence or absence of the simple figure. No response was indicated when no corresponding mark by Pens 2 or 3 followed a mark by Pen 1 (Fig. 6).

Thus/...

Thus reaction time was measured from when the first slide of a sequence was flashed onto the screen as signified by Pen 1 until Pen 1 made its next mark which in turn served as the marker for the beginning of the next reaction time measure.

Two illuminated signs "Figure Yes" for Switch 1 and "Figure No" for Switch 2 were used to remind the subject which switch to use throughout the task.

6. WHITE NOISE GENERATOR

The White Noise Generator (Fig. 7), installed in the test room, fed white noise of 20 decibels to the subject through earphones (Fig. 5, Fig. 9).

7. TEST AND CONTROL ROOMS

All apparatus, other than the earphones and the White Noise Generator, the projection screen, chair and table, the 2 labels, the 2 response switches and wires leading to the BRS 300 and the Three-Pen Recorder, was installed in the light control room. The adjacent test room was kept dark during testing except for unavoidable slight illumination through an interleading hatch between these 2 rooms. The projectors projected slides through this hatch (Fig. 8 ). All electric wires from the test room were led into the control room through this hatch in the wall. The experimenter operated the equipment and controlled the experiment from the control room.

## SUBJECTS

Subjects were 30 male university students between 19 and 22 years of age selected at random from the university corridors. Each subject was seated in the test room and was not allowed to leave the room or smoke during the test (Fig.9).

## PROCEDURE

With the apparatus switched on each subject was seated in a chair in the test room in a position facing the projection screen. Room temperature was ambient.

The following instructions which were based on Witkin's (1950) were read to each subject:

> You are going to be shown a series of geometric designs on the screen before you. The designs will be white outlines on a black background. You will be shown a simple or smaller design and then a complex or larger design, the simple or smaller design may be contained in the larger design. Your task will be to indicate the presence or absence of the smaller figure in the complex design. When present, the simple or smaller figure will always be in the same upright position, size and shape originally presented to you. This is the figure you must search for and respond to when located by pressing the response button on your left (Figure Yes); if you decide the simple figure is not present, press the button on your right (Figure No). If you have not located the simple figure within 3-minutes a new simple figure will automatically be flashed onto the screen to replace the complex figure. Avoid guessing and work as quickly and accurately as you can as your score will depend upon the speed and accuracy of your responses.

You/...

You may not trace the figures out manually.

You will now be given 2 practice trials. The first showing an example of a complex figure where the smaller figure is present and the second where the same smaller figure is absent. Throughout the study a number of different smaller or simpler and complex or larger figures will be used.

On the table before you are earphones from a White Noise Generator, these must be worn to cut out extraneous sounds. You may not smoke and must surrender your watch for the duration of the task.

Are there any questions? [Experimenter answered questions.] You will have further opportunity for questions after your practice session. I will leave the room now with the door closed and the light switched off. Your practice session will follow. Put on your earphones.

After taking possession of the subject's watch the experimenter left the test room and closed the door after switching off the light. In the control room next door the BRS 300 was activated by the experimenter and the subject was shown practice simple figure P for 10-seconds. When it was removed, P 1, the first practice complex figure, was shown until the subject responded or for 3-minutes if the subject did not respond. P was then projected again for 10-seconds and then P 1a, the second complex practice figure until the subject responded or for 3-minutes if the subject did not respond by pressing one of the 2 response switches. The apparatus except the White Noise Generator and 2 labels was immediately switched off and the experimenter re-entered

the/...

the test room and, first indicating for the subject to remove the earphones further instructed him as follows:

> Have you any questions? [Experimenter answered questions.] I will now leave you with your earphones on in the darkened room to begin the actual test. The test will last 2-hours without interruption. Have you any further questions? [The experimenter answered questions.] Put on your earphones.

The experimenter left the test room for the control room and switched on the apparatus after tearing off the trial graph from the Three-Pen Recorder. This was to allow recording to begin on a clean strip of graph paper. The trial graph, merely to test whether the subject understood the instructions, was discarded. The beginning of each graph was marked by noting the subjects number - the first subject here being subject number 4 and the last being subject number 33.

Upon switching the equipment on the BRS 300 was immediately re-activated to start the test sequence where a 10-second simple slide was followed by an appropriate complex slide until the subject responded or for 3-minutes if he did not respond. Both instances signalled the BRS 300 to flash the next simple slide onto the projection screen. This sequence was continued uninterrupted for 2-hours.

Two blank flashes occurred on the projection screen. The first was between the last practice trial and the switching off of the equipment. This was because the BRS-300 could not be stopped immediately after the last practice trial so that the next image projected was a test figure and

not/...

not a blank flash. The second blank flash occurred between switching the BRS 300 on and activating it because, when the new trays of test slides were fitted, their first space, slot 0, did not contain the first figure to be projected. This was in slot 1.

## PRESENTATION AND DISCUSSION OF RESULTS

The graphs produced by the Three-Pen Recorder were devided into quarter-hour segments. The number of responses, average reaction time, the number of errors, the percentage of false reports, and the percentage of signals (simple figures occurring in complex figures) missed were read for each subject for each ¼-hour and tabulated. (Tables 8 to 11 and 13 to 33.) The means of the scores for 30 subjects on each ¼-hour were calculated, tabulated on a table of average results of 30 subjects (Table 39), then plotted against ¼-hour devisions on Graphs (Graph 4A to 4E) to outline the average trends of results. Time on the task in eight ¼-hour segments is on the horizontal axis, $t$ , while the particular variable being considered is on the vertical axis, $y$, of each graph. The results in Table 39 were analysed using the statistical methods below to find the estimated results given in Table 40. [See Appendices 4 to 8 for calculations.]

A regression analysis was applied to the mean scores over ¼-hour periods for the group of 30 subjects. The regression equation is the equation for the regression line which/...

which is the line best expressing the trend of the points on a scatter diagram: a true regression line is the line "for which the sum of the squared deviations is as small as possible" (Smith, 1965). The constants of the equation were calculated as follows (after Smith, 1965):

The components of the product-moment correlation coeffecient, $r$, were calculated from the following formula:

$$r = \frac{[A]}{[B][C]}$$

where

$$A = \left[ n\sum t_i y_i - (\sum t_i) (\sum y_i) \right]$$

$$B = \left[ n\sum t_i^2 - (\sum t_i)^2 \right]$$

$$C = \left[ n\sum y_i^2 - (\sum y_i)^2 \right]$$

with $t_i$ = time on task in ¼-hours (¼,½,¾,1,1¼,1½,1¾,2)

$y_i$ = mean score per ¼-hour

$n$ = total number of categories (8 in this case)

The regression coefficient for $y$ upon $t$ is given by

$$b_y = \frac{[A]}{[B]}$$

where $(b_y)$ is the slope of the regression line.

To calculate the estimated value of each successive ¼-hour period of time the following equation was used:

$$ye = b_y t + (\bar{y} - \bar{t}\ b_y)$$

Where the regression line cut the vertical or $y$ axis is given by

$$(\bar{y} - \bar{t}\ b_y)$$

with

$$\bar{y} = \frac{\sum y_i}{n}$$

$$\bar{t} = \frac{\sum t_i}{n}$$

This estimated value is not a certainty, it is merely the best estimate unless it is based on a perfect correlation. It was thus necessary to ascertain the size of such errors or to know the probable limits of this potential error of the estimate. The standard error in the estimate, $S_y$, was given by

$$S_y = s_y \sqrt{1 - r^2}$$

where

$$s_y = \frac{y_i^2}{n} - \bar{y}^2$$

$S_y$ was used together with the estimated values of $y$, $\bar{y}e$, and the observed values of $y$, $\bar{y}o$, to establish confidence limits. The following limits were then calculated:

1. One standard error each side of the expected value of $y$, ($\bar{y}e$). It could have been expected in about 68 times in a 100 that a score selected at random from a normal distribution would have fallen between these limits of $\bar{y}e - 1\ S_y$ and $\bar{y}e + 1\ S_y$.
2. Similarly, chance expectation to be correct 95% for the limits $\bar{y}e - 2s_y$ and $\bar{y}e + 2s_y$ was calculated.
3. Also, chance expectation to be correct 99,74% for the limits $ye - 3\ S_y$ and $\bar{y}e + 3\ S_y$ was calculated.

The $X^2$ method for testing goodness - of-fit was then used to determine whether the differences between the theoretical and the observed results could be attributed to chance sampling variations.

The results of 26 subjects were tabulated individually (Tables 13-38 ). These, and the results of the 4 subjects (Tables 8 - 11) of the third pilot study, bringing the total

to/...

to 30 subjects, were tabulated (Table 39) as the average results of 30 subjects. The estimated results for 30 subjects were tabulated on Table 40. The results on these latter 2 tables were discussed and represented on Graphs 4A to 4E.

## DISCUSSION OF TABLES 39 AND 40 AND GRAPHS 4A TO 4E

AVERAGE NUMBER OF RESPONSES (GRAPH 4A, PAGE 177; APPENDIX 4)

The average observed number of responses per quarter-hour ranged between 36,67 at the $\frac{1}{4}$-hour and $\frac{3}{4}$-hour marks and 45,83 at the 2-hour mark with an average of 40,76 responses per quarter-hour. The difference between the beginning and end results was 9,16. The average number of observed responses increased over time on the present task. (Table 39.)

Regression coeffecient, $by$, for the average number of responses, $y$, on time, $t$, for this task was calculated. The regression coefficient, $by$, was calculated to be 5,40; this referred to the slope of the regression line. From this the equation describing the regression line followed, viz: $ye = 5{,}40t + 34{,}53$.

Using this formula the estimated average number of responses (Table 40; Graph 4A) were as follows for each $\frac{1}{4}$-hour period (Table 40, Appendix 4): 35,88; 37,23; 38,58; 39,93; 41,28; 42,63; 43,98 and 45,33. The response rate per $\frac{1}{4}$-hour at the end of the 2-hour period had increased by 10,80. A $X^2$ of 0,07 was calculated with $d.f. = 7$ reflecting a satisfactory goodness - of - fit. (Appendix 4.)

The standard error of the estimate, $S$, of $y$ was calculated to be 1,66 and used to establish confidence limits. At the 68% level these were between $\overline{ye} - 1\ Sy$ and $\overline{ye} + 1\ Sy$. (Appendix 4; Table 41.)

AVERAGE REACTION TIME IN SECONDS (GRAPH 4B, PAGE 178; APPENDIX 5)

The observed average reaction time ranged between 21,10-seconds at the 2-hour mark and 27,11-seconds at the $\frac{1}{4}$-hour mark with an average of 24,68-seconds per quarter-hour. The difference between the beginning and end results was 6,01-seconds. The average number of observed responses declined with the progression of time on the present task. This was consistent with the previous result where the number of responses per $\frac{1}{4}$-hour increased with time on the task. (Table 39.)

Regression coefficient, $by$ , for the average reaction time, $y$ , on time, $t$ , for this task was calculated. The regression coefficient, $by$ , was calculated to be 3,65. This referred to the slope of the regression line. From this the equation describing the regression line followed, viz: $ye = -3,65\ t + 28,80$.

Using this formula the estimated average reaction times (Table 40; Graph 4B) were as follows for each $\frac{1}{4}$-hour period (Table 40; Appendix 5): 27,89; 26,97; 26,06; 25,15; 24,24; 23,32; 22,41; 21,50. The reaction time in seconds per $\frac{1}{4}$-hour at the end of the 2-hour period had declined by 7,30-seconds.

A $X^2$ of 0,15 was calculated with $d.f. = 7$ reflecting a satisfactory goodness - of - fit (Appendix 5.)

The standard error of the estimate, $S$, of $y$ was calculated to be 1,90 and used to establish confidence limits. At the 68% level these were between $\overline{y}e$ - 1 $Sy$ and $\overline{y}e$ + 1 $Sy$. (Appendix 5; Table 42.)

AVERAGE NUMBER OF ERRORS (GRAPH 4C, PAGE 179; APPENDIX 6)

The observed average number of errors ranged between 7,60 at the $\frac{3}{4}$-hour mark and 10,60 at the $\frac{1}{4}$-hour mark with an average of 8,68 errors per quarter-hour. The difference between the beginning and end results was 0,40. The average number of observed errors declined over time although there appeared to be a steady increase from after the $\frac{3}{4}$-hour mark (Table 39).

Regression coefficient, $b_y$, for the average number of errors, $y$, on time, $t$, for this task was calculated. The regression coefficient, $b_y$, was calculated to be 0,29. This referred to the slope of the regression line. From this the equation describing the regression line followed, viz: $ye = 0{,}29\ t + 8{,}35$.

Using this formula the estimated average number of errors (Table 40; Graph 4C) were as follows (Table 40; Appendix 6): 8,42; 8,50; 8,57; 8,64; 8,71; 8,79; 8,86; and 8,93. The response rate per $\frac{1}{4}$-hour at the end of the 2-hour period had increased by 0,58.

A $X^2$ of 1,18 was calculated with $d.f.$ = 7 reflecting a satisfactory goodness - of - fit. (Appendix 6.)

The standard error of the estimate, $S$, of $y$ was calculated to be 1,27 and used to establish confidence limits.

At/...

At the 68% level these were between $\overline{y}e$ -1 $s_y$ and $\overline{y}e$ +1 $s_y$ except for the $\frac{1}{4}$-hour mark which was at the 95% level and was between $\overline{y}e$ - 2 $s_y$ and $\overline{y}e$ +2 $s_y$. (Appendix 6; Table 43.)

AVERAGE PERCENTAGE OF FALSE REPORTS (GRAPH 4D, PAGE 180; APPENDIX 7)

Here the observed average percentages of false reports ranged between 3,64% at the $\frac{3}{4}$-hour mark and 25,01% at the $\frac{1}{4}$-hour mark with the average being 14,40% per quarter-hour. The difference between the beginning and end results was 8,34%. The average percentage of false reports observed declined over time; performance in the latter hour was not as variable as the first and was consistently poorer. (Table 39.)

Regression coefficient, $b_y$, for the average percentage of false reports, $y$, on time, $t$, for this task was calculated. The regression coefficient, $b_y$, was calculated to be 2,42; this referred to the slope of the regression line. From this the equation describing the regression line followed, viz: $ye$ = 2,42$t$ + 11,67.

Using this formula the estimated percentages of false reports (Table 40; Graph 4D) were as follows for each $\frac{1}{4}$-hour period (Table 40; Appendix 7): 12,28%; 12,88%; 13,49%; 14,00%; 14,70%; 15,30%; 15,91%; and 16,51%. The percentage of false reports per $\frac{1}{4}$-hour at the end of the 2-hour period had increased by 4,84%.

A $X^2$ of 27,21 was calculated with $d.f.$ = 7 reflecting an unsatisfactory goodness - of - fit. (Appendix 7.)

The standard error of the estimate $S$ of $y$ was calculated to be 44,74 and used to establish confidence limits. At the 68% level these were between $\overline{y}e$ -1 $Sy$ and $\overline{y}e$ + 1 $Sy$. (Appendix 7; Table 44.)

AVERAGE PERCENTAGE OF MISSED SIGNALS (GRAPH 4E, PAGE 181; APPENDIX 8)

The observed average percentage of missed signals ranged between 40,43% at the 1¼-hour mark and 59,38% at the 2-hour mark with an average of 48,43% per ¼-hour. The difference between the beginning and end results was 3,68%. There was a decrement in performance over time. (Table 39.)

The regression coefficient, $b_y$, for the average percentage of missed signals, $y$, on time, $t$, was calculated. The regression coefficient, $b_y$, was calculated to be 0,45; this referred to the slope of the regression line. From this the equation describing the regression line followed, viz: $ye = 0{,}45t + 47{,}92$.

Using this formula the estimated average percentages of missed signals (Table 40; Graph 4E) were as follows for each ¼-hour period (Table 40; Appendix 8) : 48,03%; 48,15%; 48,26%; 48,37%; 48,48%; 48,60%; 48,71%; and 48,82%;. The percentage of missed signals per ¼-hour at the end of the 2-hour period had increased by 0,90%.

A $X^2$ of 6,35 was calculated with $d.f.$ = 7 reflecting a satisfactory goodness - of - fit. (Appendix 8.)

The standard error of the estimate, $S$, of $y$ was calculated to be 12,31 and used to establish confidence limits. At the 68% level these were between $\overline{y}e$ - 1 $Sy$ and $\overline{y}e$+ 1 $Sy$. (Appendix 8; Table 45.)

Table 13 Subject Number 8.

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen - tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 51 | 17,65 | 11 | 15,91 | 57,14 |
| ½ | 46 | 19,57 | 8 | 10,26 | 57,14 |
| ¾ | 51 | 17,65 | 12 | 16,67 | 55,56 |
| 1 | 53 | 16,98 | 10 | 18,75 | 20,00 |
| 1¼ | 52 | 17,31 | 8 | 4,65 | 16,67 |
| 1½ | 44 | 20,45 | 10 | 18,42 | 50,00 |
| 1¾ | 48 | 18,75 | 16 | 25,00 | 75,00 |
| 2 | 58 | 15,52 | 9 | 5,88 | 86,71 |

Table 14 Subject Number 9

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen- tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 31 | 29,03 | 12 | 37,04 | 50,00 |
| ½ | 29 | 31,03 | 6 | 15,38 | 66,67 |
| ¾ | 37 | 24,32 | 11 | 20,00 | 71,43 |
| 1 | 37 | 69,23 | 8 | 18,75 | 40,00 |
| 1¼ | 40 | 22,50 | 10 | 17,65 | 66,67 |
| 1½ | 41 | 21,95 | 7 | 17,14 | 16,67 |
| 1¾ | 41 | 21,95 | 10 | 20,00 | 50,00 |
| 2 | 47 | 19,15 | 9 | 12,82 | 50,00 |

Table 15 Subject Number 10

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 67 | 13,43 | 14 | 20,00 | 28,57 |
| ½ | 67 | 13,43 | 13 | 5,45 | 88,33 |
| ¾ | 69 | 13,04 | 16 | 13,13 | 88,89 |
| 1 | 69 | 13,04 | 13 | 1,79 | 92,31 |
| 1¼ | 79 | 11,39 | 15 | 11,43 | 77,78 |
| 1½ | 71 | 12,68 | 16 | 11,29 | 100,00 |
| 1¾ | 72 | 12,50 | 14 | 55,56 | 83,33 |
| 2 | 71 | 12,68 | 11 | 7,81 | 85,71 |

Table 16 Subject Number 11

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 35 | 25,71 | 20 | 54,18 | 50,00 |
| ½ | 37 | 24,32 | 13 | 33,33 | 50,00 |
| ¾ | 36 | 25,00 | 10 | 25,00 | 37,50 |
| 1 | 47 | 18,37 | 7 | 17,50 | 0,00 |
| 1¼ | 41 | 21,95 | 13 | 36,11 | 0,00 |
| 1½ | 49 | 18,37 | 12 | 22,73 | 44,00 |
| 1¾ | 53 | 16,98 | 9 | 20,93 | 0,00 |
| 2 | 53 | 16,98 | 14 | 28,89 | 12,50 |

Table 17 Subject Number 12

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen - tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 29 | 31,03 | 9 | 32,00 | 25,00 |
| ½ | 25 | 36,00 | 4 | 16,00 | 0,00 |
| ¾ | 22 | 40,91 | 5 | 13,64 | 50,00 |
| 1 | 26 | 34,62 | 1 | 3,85 | 0,00 |
| 1¼ | 28 | 32,14 | 3 | 4,35 | 40,00 |
| 1½ | 31 | 29,03 | 5 | 14,81 | 25,00 |
| 1¾ | 32 | 28,13 | 4 | 13,79 | 0,00 |
| 2 | 39 | 23,08 | 4 | 11,43 | 0,00 |

Table 18 Subject Number 13

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen- tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 31 | 29,03 | 10 | 29,63 | 50,00 |
| ½ | 45 | 20,00 | 7 | 14,63 | 25,00 |
| ¾ | 45 | 20,00 | 7 | 10,81 | 37,50 |
| 1 | 45 | 20,00 | 11 | 18,42 | 57,14 |
| 1¼ | 48 | 18,75 | 8 | 19,05 | 0,00 |
| 1½ | 50 | 18,00 | 9 | 18,60 | 14,29 |
| 1¾ | 52 | 17,31 | 7 | 9,52 | 30,00 |
| 2 | 52 | 17,31 | 14 | 25,53 | 40,00 |

Table 19 Subject Number 14

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen - tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 19 | 47,37 | 5 | 12,50 | 100,00 |
| ½ | 20 | 45,00 | 6 | 31,58 | 0,00 |
| ¾ | 18 | 50,00 | 5 | 20,00 | 66,67 |
| 1 | 18 | 50,00 | 4 | 18,75 | 50,00 |
| 1¼ | 18 | 50,00 | 4 | 7,14 | 75,00 |
| 1½ | 20 | 45,00 | 4 | 6,67 | 75,00 |
| 1¾ | 24 | 37,50 | 5 | 23,81 | 0,00 |
| 2 | 25 | 36,00 | 8 | 20,00 | 80,00 |

Table 20 Subject Number 15

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen- tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 16 | 56,25 | 3 | 14,29 | 50,00 |
| ½ | 18 | 50,00 | 7 | 37,50 | 50,00 |
| ¾ | 22 | 40,91 | 7 | 31,58 | 33,33 |
| 1 | 23 | 39,13 | 5 | 20,00 | 33,33 |
| 1¼ | 25 | 36,00 | 4 | 9,52 | 50,00 |
| 1½ | 27 | 33,33 | 3 | 4,55 | 40,00 |
| 1¾ | 26 | 34,62 | 4 | 9,52 | 40,00 |
| 2 | 31 | 29,03 | 4 | 11,11 | 25,00 |

Table 21 Subject Number 16

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 52 | 17,31 | 18 | 26,67 | 85,71 |
| $\frac{1}{2}$ | 36 | 25,00 | 13 | 32,26 | 60,00 |
| $\frac{3}{4}$ | 28 | 32,14 | 9 | 28,00 | 66,67 |
| 1 | 25 | 36,00 | 8 | 28,57 | 50,00 |
| $1\frac{1}{4}$ | 29 | 31,03 | 11 | 33,33 | 60,00 |
| $1\frac{1}{2}$ | 28 | 32,14 | 13 | 43,48 | 60,00 |
| $1\frac{3}{4}$ | 34 | 26,47 | 12 | 36,67 | 25,00 |
| 2 | 34 | 26,47 | 15 | 37,04 | 71,43 |

Table 22 Subject Number 17

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 44 | 20,45 | 12 | 23,08 | 60,00 |
| $\frac{1}{2}$ | 41 | 21,95 | 11 | 22,86 | 50,00 |
| $\frac{3}{4}$ | 36 | 25,00 | 3 | 6,67 | 16,67 |
| 1 | 38 | 23,68 | 1 | 0,00 | 14,29 |
| $1\frac{1}{4}$ | 42 | 21,43 | 7 | 12,50 | 25,00 |
| $1\frac{1}{2}$ | 44 | 20,45 | 6 | 7,89 | 50,00 |
| $1\frac{3}{4}$ | 47 | 19,15 | 3 | 5,26 | 11,11 |
| 2 | 46 | 19,57 | 8 | 12,50 | 50,00 |

Table 23 Subject Number 18

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen - tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 30 | 30,00 | 10 | 26,92 | 75,00 |
| ½ | 39 | 23,08 | 8 | 13,89 | 100,00 |
| ¾ | 42 | 21,43 | 7 | 6,25 | 50,00 |
| 1 | 41 | 21,95 | 7 | 11,76 | 46,86 |
| 1¼ | 40 | 22,50 | 3 | 8,33 | 0,00 |
| 1½ | 40 | 22,50 | 6 | 13,51 | 33,33 |
| 1¾ | 46 | 19,57 | 12 | 19,44 | 50,00 |
| 2 | 40 | 22,50 | 14 | 30,30 | 59,14 |

Table 24 Subject Number 19

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen- tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 50 | 18,00 | 17 | 30,23 | 57,14 |
| ½ | 51 | 17,65 | 10 | 15,09 | 46,86 |
| ¾ | 50 | 18,00 | 8 | 10,00 | 40,00 |
| 1 | 49 | 18,37 | 13 | 26,67 | 25,00 |
| 1¼ | 49 | 18,37 | 11 | 24,39 | 12,50 |
| 1½ | 49 | 18,37 | 7 | 4,29 | 4,29 |
| 1¾ | 49 | 18,37 | 11 | 19,51 | 37,50 |
| 2 | 50 | 18,00 | 14 | 23,40 | 60,00 |

Table 25 Subject Number 20

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 27 | 33,33 | 5 | 17,39 | 25,00 |
| $\frac{1}{2}$ | 26 | 34,62 | 3 | 13,04 | 0,00 |
| $\frac{3}{4}$ | 32 | 28,13 | 6 | 10,71 | 75,00 |
| 1 | 34 | 26,47 | 1 | 0,00 | 16,67 |
| $1\frac{1}{4}$ | 37 | 24,32 | 6 | 33,33 | 71,43 |
| $1\frac{1}{2}$ | 41 | 21,95 | 7 | 24,32 | 50,00 |
| $1\frac{3}{4}$ | 44 | 20,45 | 5 | 7,89 | 33,33 |
| 2 | 46 | 19,57 | 5 | 2,70 | 44,44 |

Table 26 Subject Number 21

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 36 | 25,00 | 10 | 25,00 | 50,00 |
| $\frac{1}{2}$ | 34 | 26,47 | 1 | 3,23 | 0,00 |
| $\frac{3}{4}$ | 25 | 36,00 | 4 | 15,79 | 16,67 |
| 1 | 33 | 27,27 | 2 | 0,00 | 33,33 |
| $1\frac{1}{4}$ | 28 | 32,14 | 4 | 4,35 | 60,00 |
| $1\frac{1}{2}$ | 25 | 36,00 | 5 | 18,18 | 33,33 |
| $1\frac{3}{4}$ | 28 | 32,14 | 2 | 8,33 | 0,00 |
| 2 | 34 | 26,47 | 2 | 3,25 | 33,33 |

Table 27 Subject Number 22

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen - tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 27 | 33,33 | 5 | 13,04 | 50,00 |
| ½ | 27 | 33,33 | 7 | 25,00 | 33,33 |
| ¾ | 27 | 33,33 | 7 | 20,83 | 66,67 |
| 1 | 25 | 36,00 | 2 | 10,00 | 0,00 |
| 1¼ | 24 | 37,50 | 2 | 10,00 | 0,00 |
| 1½ | 23 | 39,13 | 2 | 11,11 | 0,00 |
| 1¾ | 26 | 34,62 | 4 | 16,67 | 0,00 |
| 2 | 27 | 33,33 | 4 | 16,67 | 0,00 |

Table 28 Subject Number 23

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen- tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 39 | 23,08 | 9 | 20,00 | 50,00 |
| ½ | 48 | 18,75 | 8 | 15,00 | 25,00 |
| ¾ | 48 | 18,75 | 4 | 4,88 | 28,57 |
| 1 | 47 | 19,15 | 10 | 12,82 | 62,50 |
| 1¼ | 50 | 18,00 | 6 | 13,04 | 0,00 |
| 1½ | 50 | 18,00 | 6 | 10,00 | 20,00 |
| 1¾ | 50 | 18,00 | 8 | 7,32 | 55,56 |
| 2 | 57 | 15,79 | 10 | 12,00 | 57,14 |

Table 29 Subject Number 24

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen - tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 42 | 21,43 | 11 | 23,68 | 50,00 |
| ½ | 49 | 18,57 | 8 | 12,50 | 33,33 |
| ¾ | 47 | 19,15 | 4 | 2,50 | 42,86 |
| 1 | 43 | 20,93 | 10 | 16,67 | 42,86 |
| 1¼ | 48 | 18,75 | 3 | 6,82 | 0,00 |
| 1½ | 49 | 18,37 | 4 | 7,68 | 10,00 |
| 1¾ | 50 | 18,00 | 7 | 9,52 | 37,50 |
| 2 | 51 | 17,65 | 13 | 17,78 | 83,33 |

Table 30 Subject Number 25

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen- tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| ¼ | 24 | 37,50 | 6 | 12,29 | 100,00 |
| ½ | 29 | 31,03 | 7 | 16,00 | 75,00 |
| ¾ | 35 | 25,71 | 8 | 10,00 | 100,00 |
| 1 | 36 | 25,00 | 6 | 33,33 | 83,33 |
| 1¼ | 40 | 22,50 | 11 | 12,12 | 71,43 |
| 1½ | 43 | 20,93 | 6 | 7,90 | 60,00 |
| 1¾ | 45 | 20,00 | 7 | 5,13 | 83,33 |
| 2 | 33 | 27,27 | 8 | 10,71 | 100,00 |

Table 31 Subject Number 26

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen - tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| 1/4 | 28 | 32,14 | 5 | 12,50 | 50,00 |
| 1/2 | 35 | 25,71 | 8 | 15,63 | 100,00 |
| 3/4 | 37 | 24,32 | 7 | 13,33 | 42,86 |
| 1 | 44 | 20,45 | 8 | 10,81 | 57,14 |
| 1 1/4 | 40 | 22,50 | 7 | 14,71 | 33,33 |
| 1 1/2 | 46 | 19,57 | 6 | 7,14 | 75,00 |
| 1 3/4 | 43 | 20,93 | 8 | 12,12 | 40,00 |
| 2 | 49 | 18,37 | 8 | 7,14 | 71,43 |

Table 32 Subject Number 27

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen- tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| 1/4 | 40 | 22,50 | 12 | 27,78 | 50,00 |
| 1/2 | 32 | 28,13 | 10 | 25,00 | 75,00 |
| 3/4 | 35 | 25,71 | 10 | 22,22 | 50,00 |
| 1 | 37 | 24,32 | 14 | 31,25 | 80,00 |
| 1 1/4 | 44 | 20,45 | 13 | 21,62 | 74,43 |
| 1 1/2 | 48 | 18,75 | 8 | 11,36 | 75,00 |
| 1 3/4 | 56 | 16,07 | 16 | 23,91 | 50,00 |
| 2 | 58 | 15,52 | 16 | 16,33 | 88,89 |

Table 33 Subject Number 28

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen - tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 31 | 29,03 | 15 | 51,85 | 25,00 |
| $\frac{1}{2}$ | 30 | 30,00 | 14 | 48,15 | 33,33 |
| $\frac{3}{4}$ | 27 | 33,33 | 13 | 50,00 | 40,00 |
| 1 | 34 | 26,47 | 10 | 31,03 | 20,00 |
| $1\frac{1}{4}$ | 34 | 26,47 | 12 | 37,04 | 28,57 |
| $1\frac{1}{2}$ | 39 | 23.08 | 16 | 45,71 | 25,00 |
| $1\frac{3}{4}$ | 40 | 22,50 | 18 | 50,00 | 0,00 |
| 2 | 46 | 19,57 | 17 | 40,54 | 22,22 |

Table 34 Subject Number 29

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percen- tage of False Reports | Percen- tage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 41 | 21,95 | 13 | 27,07 | 75,00 |
| $\frac{1}{2}$ | 43 | 20,93 | 5 | 10,81 | 16,69 |
| $\frac{3}{4}$ | 41 | 21,95 | 5 | 6,06 | 37,50 |
| 1 | 49 | 18,37 | 3 | 2,38 | 28,57 |
| $1\frac{1}{4}$ | 60 | 15,00 | 7 | 9,26 | 33,33 |
| $1\frac{1}{2}$ | 56 | 16,07 | 15 | 13,64 | 75,00 |
| $1\frac{3}{4}$ | 52 | 17,31 | 14 | 17,78 | 85,71 |
| 2 | 53 | 16,98 | 9 | 8,33 | 100,00 |

Table 35 Subject Number 30

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 25 | 36,00 | 9 | 23,90 | 100,00 |
| $\frac{1}{2}$ | 20 | 45,00 | 5 | 27,78 | 0,00 |
| $\frac{3}{4}$ | 21 | 42,86 | 5 | 25,00 | 0,00 |
| 1 | 25 | 36,00 | 5 | 15,79 | 33,33 |
| $1\frac{1}{4}$ | 25 | 36,00 | 3 | 14,29 | 0,00 |
| $1\frac{1}{2}$ | 27 | 33,33 | 4 | 13,04 | 25,00 |
| $1\frac{3}{4}$ | 32 | 28,13 | 8 | 14,29 | 100,00 |
| 2 | 37 | 24,32 | 9 | 14,84 | 50,00 |

Table 36 Subject Number 31

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 55 | 16,36 | 9 | 6,25 | 85,71 |
| $\frac{1}{2}$ | 61 | 14,75 | 12 | 1,96 | 100,00 |
| $\frac{3}{4}$ | 62 | 14,50 | 9 | 1,89 | 88,89 |
| 1 | 59 | 15,25 | 12 | 11,54 | 85,71 |
| $1\frac{1}{4}$ | 66 | 13,64 | 13 | 11,85 | 100,00 |
| $1\frac{1}{2}$ | 65 | 13,85 | 10 | 5,26 | 87,50 |
| $1\frac{3}{4}$ | 66 | 13,64 | 14 | 5,45 | 100,00 |
| 2 | 68 | 13,24 | 9 | 1,69 | 88,89 |

Table 37 Subject Number 32

| Time in Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 39 | 23,08 | 9 | 20,00 | 50,00 |
| $\frac{1}{2}$ | 44 | 20,45 | 3 | 2,63 | 33,33 |
| $\frac{3}{4}$ | 46 | 19,57 | 4 | 2,70 | 33,33 |
| 1 | 51 | 17,65 | 10 | 9,30 | 75,00 |
| $1\frac{1}{4}$ | 55 | 16,36 | 4 | 6,12 | 16,67 |
| $1\frac{1}{2}$ | 58 | 15,52 | 8 | 6,25 | 50,00 |
| $1\frac{3}{4}$ | 53 | 16,98 | 4 | 4,44 | 25,00 |
| 2 | 54 | 16,67 | 6 | 8,33 | 33,33 |

Table 38 Subject Number 33

| Time Quarter - Hour Divisions | Number of Responses | Average Reaction Time in Seconds | Number of Errors | Percentage of False Reports | Percentage of Missed Signals |
|---|---|---|---|---|---|
| $\frac{1}{4}$ | 42 | 21,43 | 8 | 18,33 | 0,00 |
| $\frac{1}{2}$ | 41 | 21,95 | 10 | 17,14 | 66,67 |
| $\frac{3}{4}$ | 39 | 23,08 | 10 | 15,63 | 71,43 |
| 1 | 41 | 21,95 | 12 | 15,15 | 87,50 |
| $1\frac{1}{4}$ | 41 | 21,95 | 10 | 16,22 | 100,00 |
| $1\frac{1}{2}$ | 47 | 19,15 | 8 | 7,69 | 62,50 |
| $1\frac{3}{4}$ | 49 | 18,37 | 15 | 15,85 | 100,00 |
| 2 | 53 | 16,98 | 20 | 26,67 | 100,00 |

Table 39 Average Observed Results of Subjects Numbers 4 to 33

| Average Observed Results | | | | | |
|---|---|---|---|---|---|
| Time in Quarter-Hour Divisions | Average Number of Responses | Mean of the Average Reaction Time in Seconds | Average Number of Errors | Average Percentage of False Reports | Average Percentage of Missed Signals |
| $\frac{1}{4}$ | 36,67 | 27,11 | 10,60 | 25,01 | 55,70 |
| $\frac{1}{2}$ | 37,93 | 26,39 | 8,00 | 4,19 | 46,44 |
| $\frac{3}{4}$ | 37,67 | 26,67 | 7,60 | 3,64 | 51,05 |
| 1 | 39,53 | 26,68 | 7,63 | 15,58 | 41,31 |
| $1\frac{1}{4}$ | 41,40 | 24,24 | 7,93 | 16,04 | 40,43 |
| $1\frac{1}{2}$ | 42,57 | 23,26 | 8,00 | 14,90 | 47,86 |
| $1\frac{3}{4}$ | 44,47 | 21,92 | 9,47 | 19,18 | 45,26 |
| 2 | 45,83 | 21,10 | 10,20 | 16,67 | 59,38 |
| Average per $\frac{1}{4}$ - Hour | 40,76 | 24,68 | 8,68 | 14,40 | 48,43 |
| Difference Between Beginning and End Results | 9,16 | 6,01 | 0,40 | 8,34 | 3,68 |

Table 40 Average Estimated Results of Subject Numbers 4 to 33

| Average Estimated Results | | | | | |
|---|---|---|---|---|---|
| Time in Quarter-Hour Divisions | Average Number of Responses | Mean of the Average Reaction Time in Seconds | Average Number of Errors | Average Percentage of False Reports | Average Percentage of Missed Signals |
| $\frac{1}{4}$ | 35,88 | 27,89 | 8,42 | 12,28 | 48,03 |
| $\frac{1}{2}$ | 37,23 | 26,97 | 8,50 | 12,88 | 48,15 |
| $\frac{3}{4}$ | 38,58 | 26,06 | 8,57 | 13,49 | 48,26 |
| 1 | 39,93 | 25,15 | 8,64 | 14,00 | 48,37 |
| $1\frac{1}{4}$ | 41,28 | 24,24 | 8,71 | 14,70 | 48,48 |
| $1\frac{1}{2}$ | 42,63 | 23,32 | 8,79 | 15,30 | 48,60 |
| $1\frac{3}{4}$ | 43,98 | 22,41 | 8,86 | 15,91 | 48,71 |
| 2 | 45,33 | 21,50 | 8,93 | 16,51 | 48,82 |
| Average per $\frac{1}{4}$-Hour | 40,23 | 24,69 | 8,70 | 14,38 | 48,43 |

FIG. 15 GRAPH 4A FOR TABLES 39 AND 40

AVERAGE OBSERVED AND ESTIMATED NUMBER OF RESPONSES

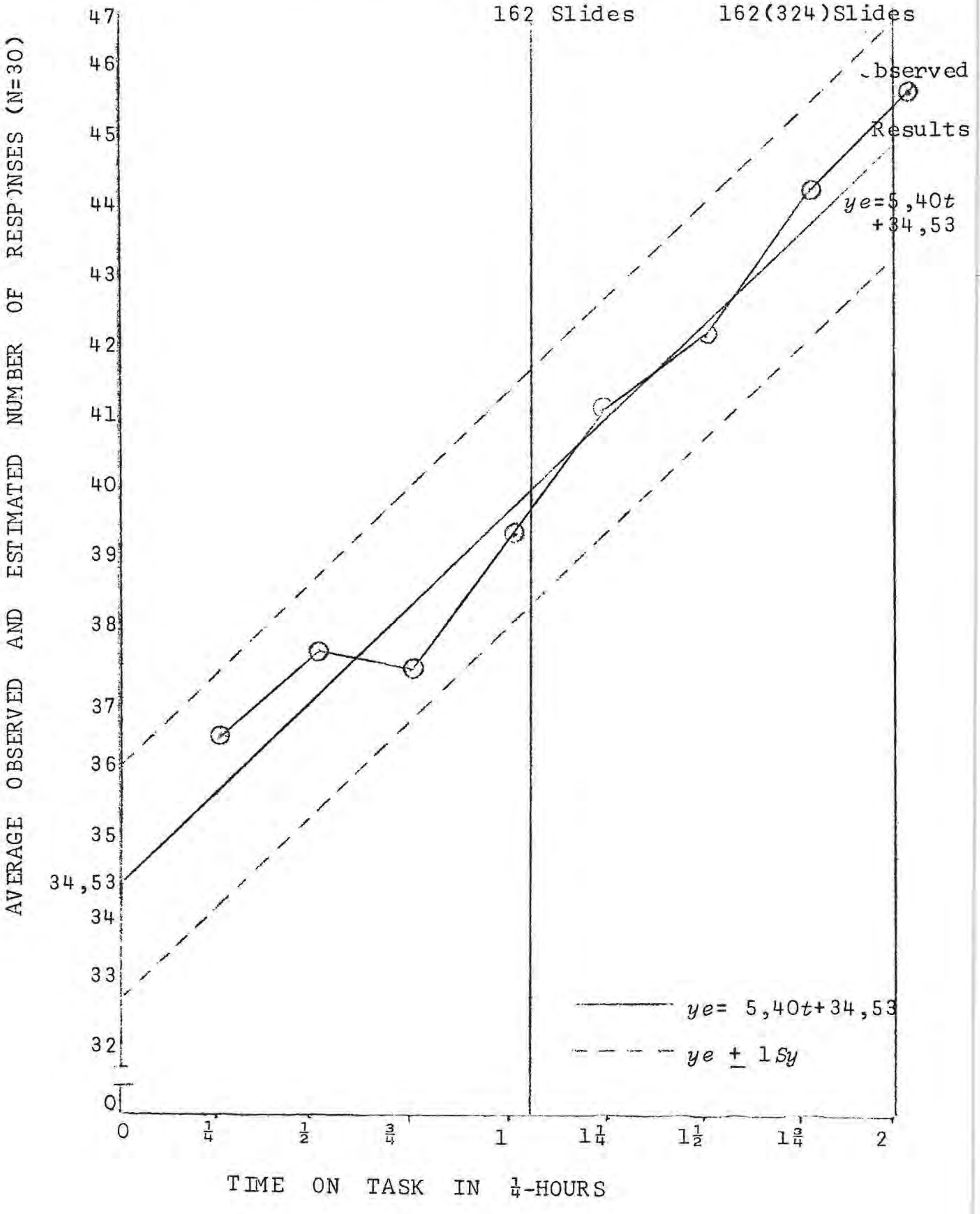


FIG. 15 GRAPH 4B FOR TABLES 39 AND 40

AVERAGE OBSERVED AND ESTIMATED

REACTION TIME IN SECONDS

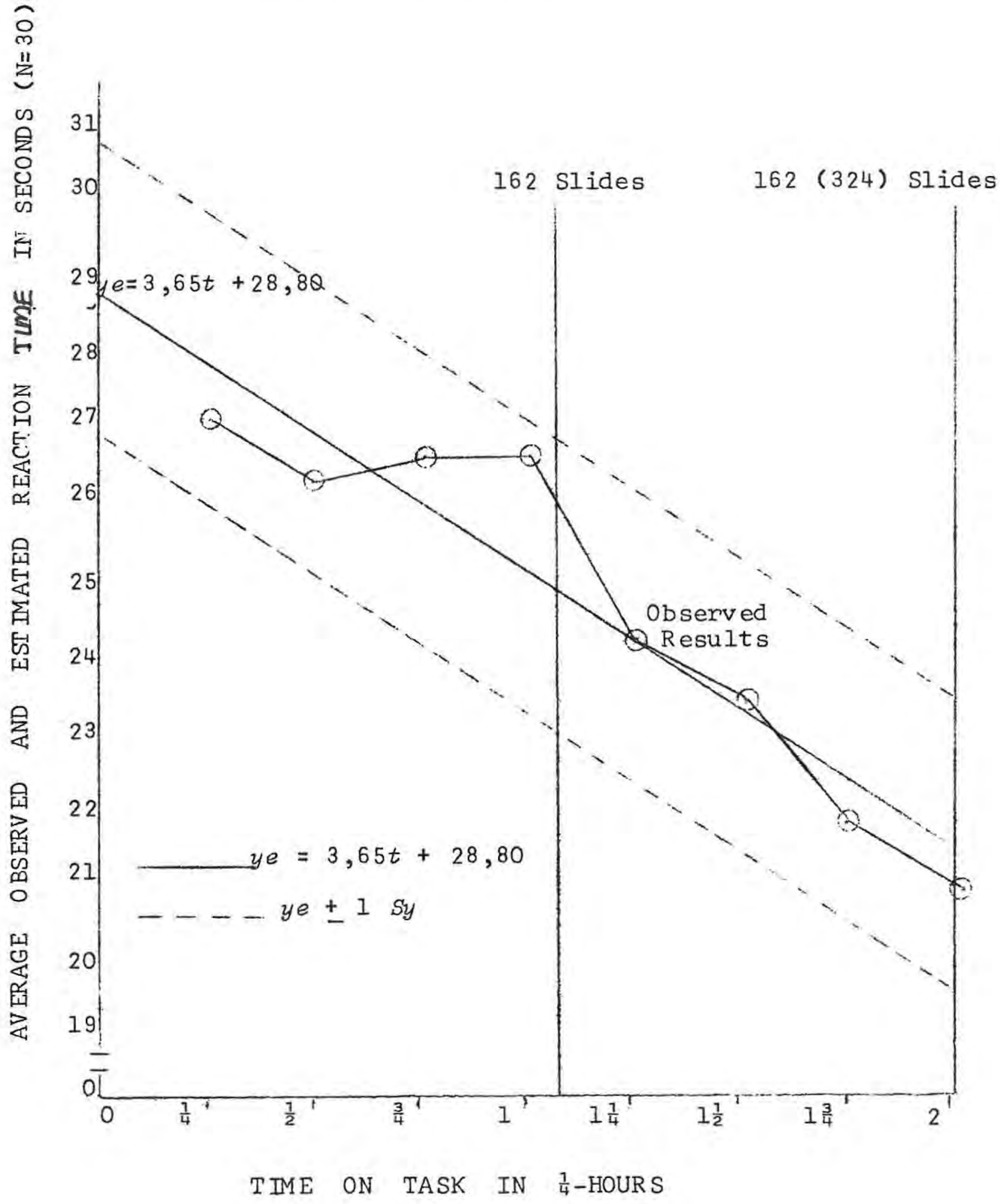


FIG. 15 GRAPH 4 C FOR TABLES 39 AND 40

AVERAGE OBSERVED AND ESTIMATED

NUMBER OF ERRORS

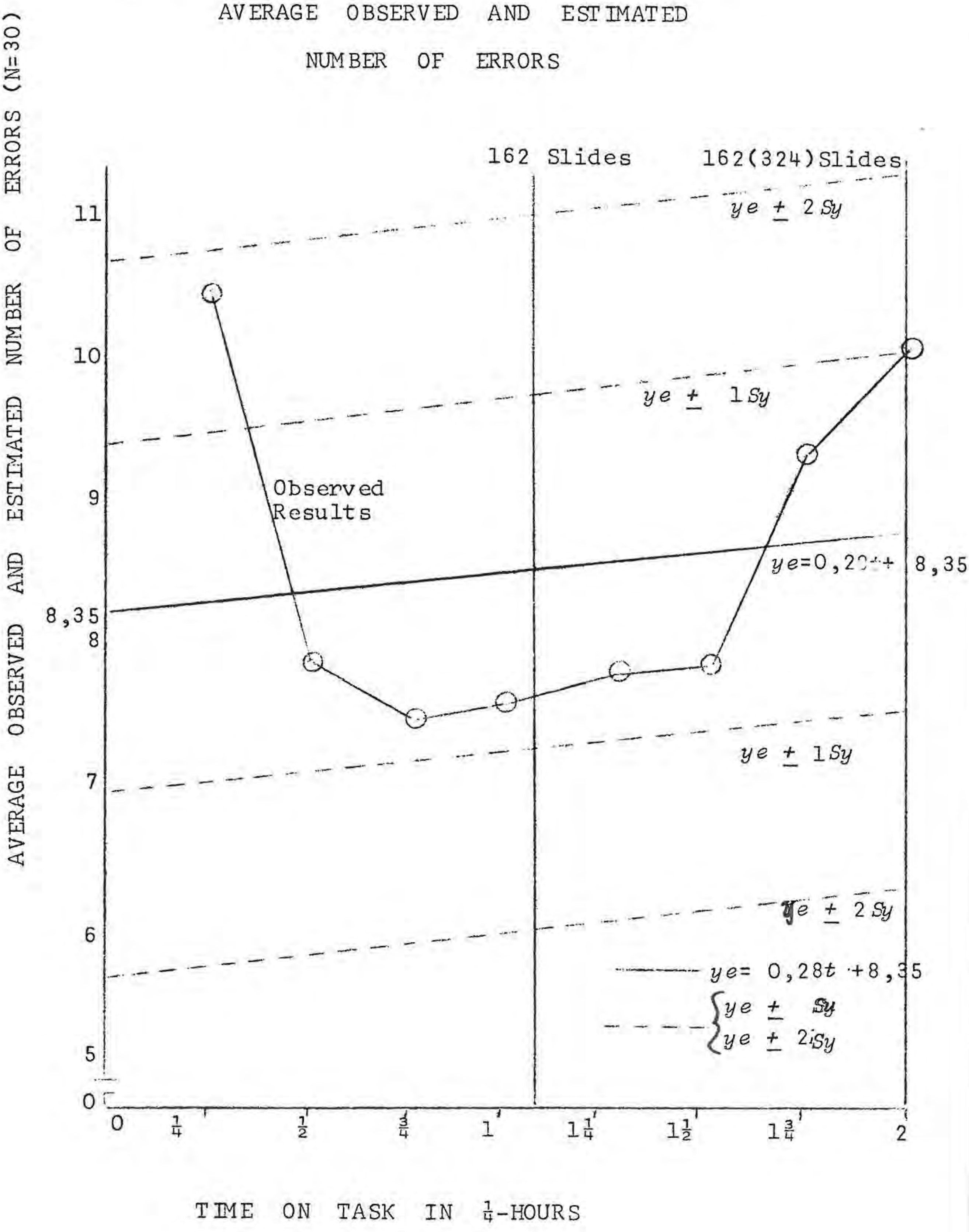


FIG. 15 GRAPH 4D FOR TABLES 39 AND 40

AVERAGE OBSERVED AND ESTIMATED PERCENTAGES OF FALSE REPORTS

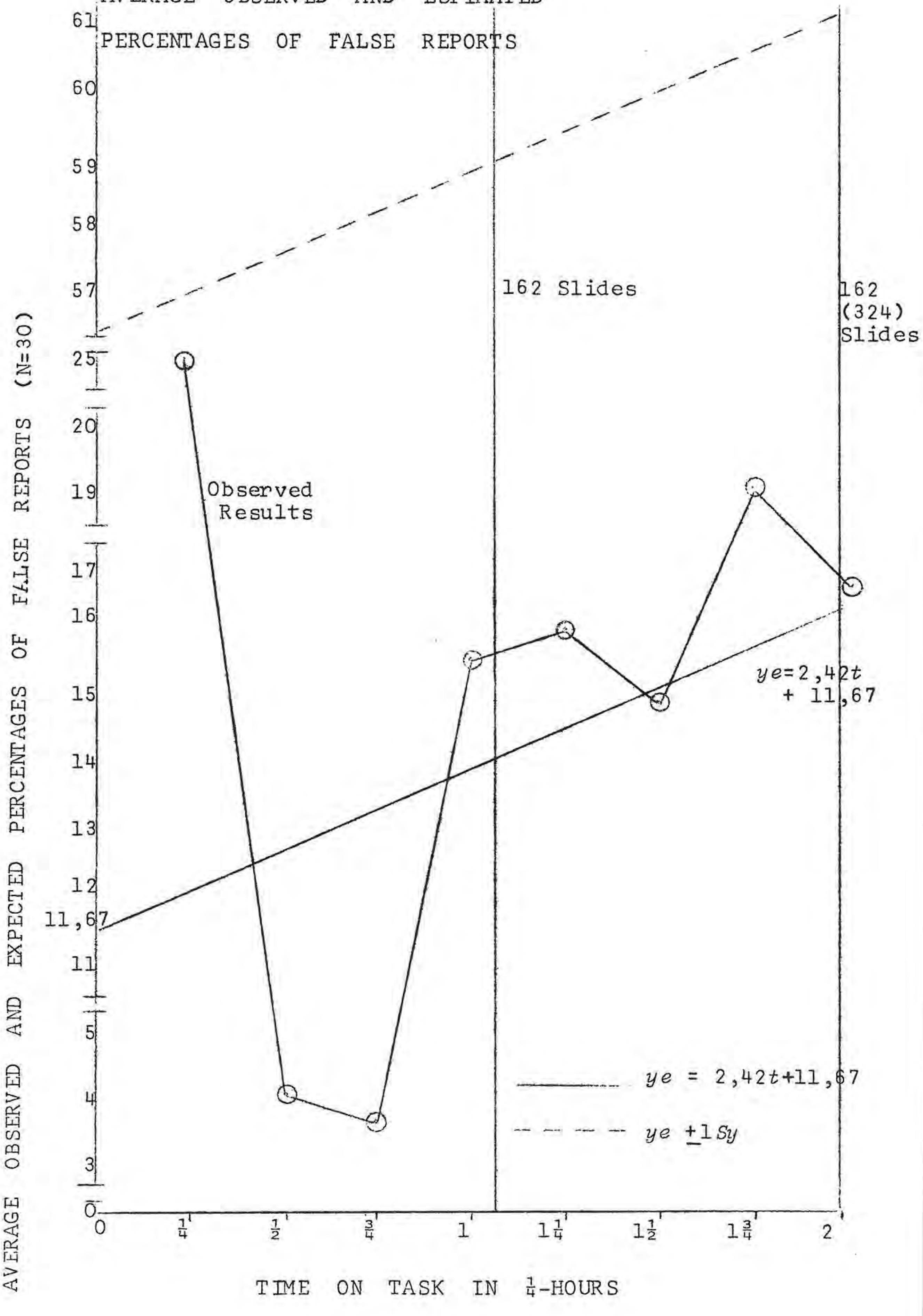
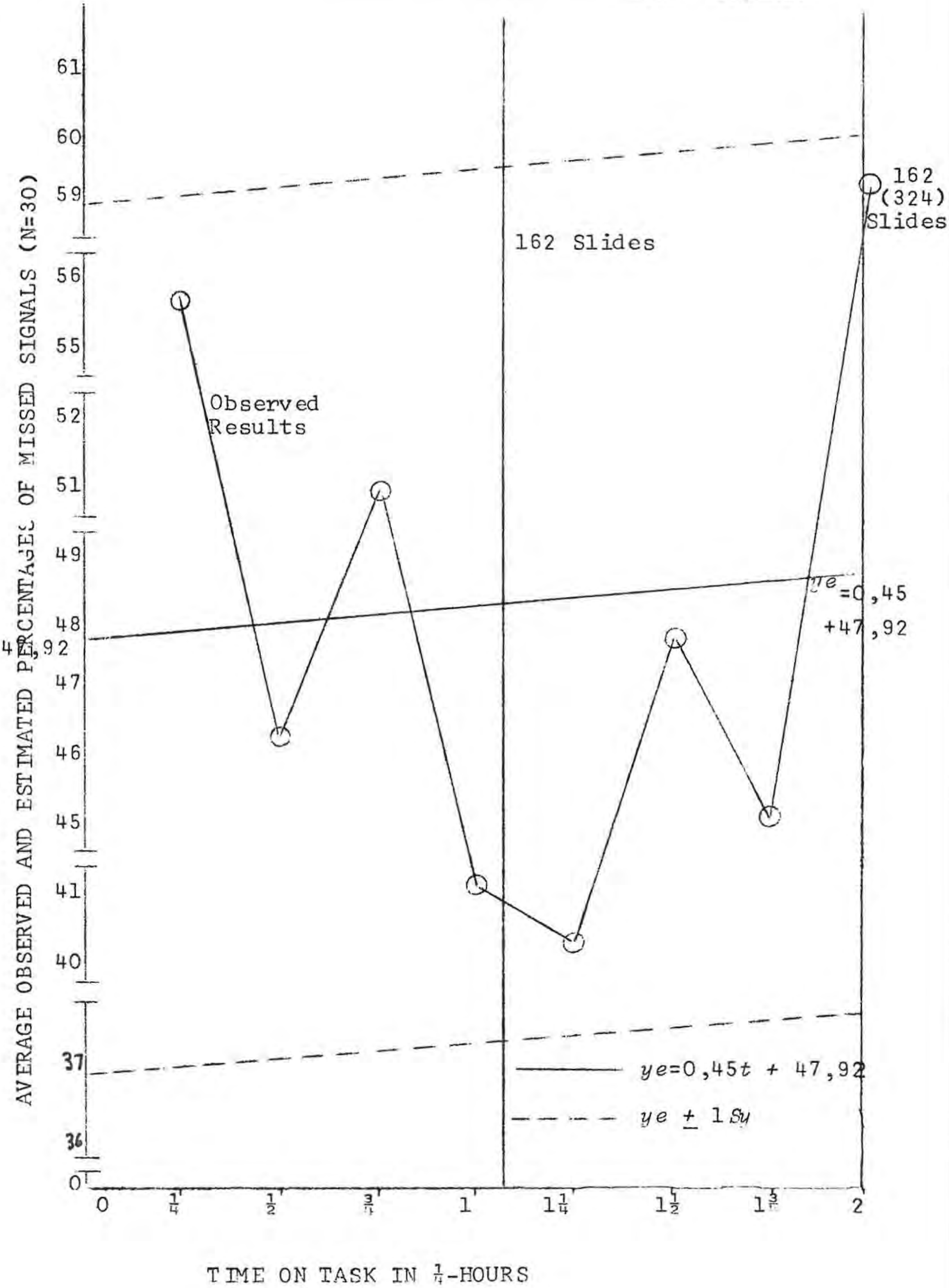


FIG.15 GRAPH 4E FOR TABLES 39 AND 40 AVERAGE OBSERVED AND ESTIMATED PERCENTAGES OF MISSED SIGNALS



# CHAPTER VIII

# CONCLUSION

# CHAPTER VIII

# C O N C L U S I O N

The only results which reflected an unsatisfactory goodness - of - fit were those of the average percentage of false reports.

In the present task response time in seconds declined over time while the number of signals presented increased over time. This relation was because the signals were displayed till responded to and so signal rate was dependent on response time. In no instance did a subject fail to respond within the 3-minute time limit.

There is a large body of literature suggesting that irregular signals occurring at a low average rate should have a detremental effect on performance. Smith, Warm, and Alliusi (1966) confirmed this when they found reaction time to decline as the signal rate increased irrespective of which coefficient of signal variability they used. They also found reaction time and signal rate to be related where unlimited stimulus duration had been used. Similarly, among many others, McCormack and Prysiazniuk (1961) and Frankmann and Adams (1962) found the same. Lisper (1969) however showed a rise in reaction time for a high signal rate and a constant reaction time for a low rate. This discrepancy between his results and those of ordinary vigilance experiments was put down to the fact that his task required a low value of attention as the signals he used were/...

were strong. It is possible that signal strength in the present task might have been partly responsible for the decline over time in observed average reaction time in seconds. Findings on the location of signals on a radar screen have repeatedly demonstrated that the portion of the radar screen upon which most of the signals fell was attended to most frequently (Deese and Ormond, 1953 cited by Frankmann and Adams, 1962 ; Nicely and Miller, 1957 cited by Buckner and McGrath, 1963). Similarly on the present task the subjects probably learned that the complex figures usually contained the simple figure in the middle, this possibly increased signal strength and so their speed of response increased, whether their response was correct or incorrect.

Vigilance tasks with irregular and infrequent critical signals have been shown to lead to a rise in errors over time (inter alia, Mackworth, N.H., 1956; Baker, 1959b.) Errors have also been shown to increase markedly in self-paced tasks (Saldahna, 1955 cited by Mackworth, J.F., 1969). The present task is self paced with irregular and infrequent critical signals and so a rise in errors was expected. Broadbent (1953b) and Wilkinson (1961) showed that subjects may maintain their speed of reaction time at the expense of increasing errors with increasing time on the task (Mackworth, J.F. 1964b). The present task just failed to show an increase in the average number of errors observed which in fact showed a U-shaped curve indicating a decline in errors followed by a rise. There did

not/...

not appear to be a relation between the average number of errors observed and the average reaction time observed as practically the same average number of errors were made for both the highest and the lowest average observed reaction times.

Perhaps a consideration of the effect of signal duration will throw light on the results. Adams (1956) had found stimulus duration to effect the average level of detection of an aperiodically presented low - intensity visual stimulus in a positive manner; signals of 2-seconds length had a higher probability of detection than those of 1-second. The long duration of stimuli allowed them to escape detection less often said Baker (1959c),who later (1962) found that short signals generated an inferior initial performance compared to long signals and gave rise to a steeper performance decrement in his 1-minute (short) and 2-hour (long) vigilance tasks. Buck (1966) found a high detection rate with long signal duration and high signal intensity, that is, when the signals were not transient (at a low critical level). Mayzner, Treselt, and Pezenik (1968) presented subjects with 2 lines of 10 letters each and required them to detect a target letter common to both lines. Their results showed that as display time increased systematically by 2-seconds, the number of correct detections increased in a relatively linear fashion. Warm, Loeb, and Alliusi (1970) found that the probability of correct detections increased monotonically with rises in

signal/ ...

signal duration. A stable rate of almost 100% was neared at signal durations of 4 and 8 - seconds, independently of signal rates (6,12, 24,48, and 96 signals per hour). The durations of 4 and 8 - seconds were in general agreement with a previous report that signal detections almost always occurred within 2-seconds in a short term free response detection task (Egan, Greenberg, and Schulman, 1961 cited by Warm et al, 1970). In the light of these figures it is surprising that any decrement in signal detection occurred at all on the present task. The increase in signal rate with the decline in reaction time possibly decreased the probability of detection just enough to lead to the significant decline in the average observed percentages of missed signals.

According to Jenkins (1958), and as illustrated above, where probability based on a rapid signal rate was high, the subject adopted a liberal criterion for accepting a current stimulus as a signal. This condition raised the frequency of false reports and was thus a sign of decrement of performance. The decline in the average observed percentage of false reports could be considered in the light of either of the following 2 considerations:

1. A decline in detections during a vigilance task was usually accompanied by a decline in false alarms, especially for the first session ( McGrath, 1963 in Buckner and McGrath, 1963 ).

2. McGrath (*ibid*) also said that false detection rate

declined/...

declined rapidly with practice, the majority of them occurring during the first watch. False detections, therefore, he said, may only be a useful index of learning but not a good one of vigilance performance. They may only reflect the subjects stability of criterion as to what is and is not a signal.

The present task found the observed average percentages of false reports to decline with time on the task though the estimated results was an increase. Possibly the estimated results could be put down to the subject's adoption of a liberal criterion perhaps indicated by the rise in the average number of responses, the accompanying decrease in average observed reaction time, and the rise in the observed percentages of missed signals. The results here are inconsistent with the estimated results as the decline in the average observed percentage of false reports showed the presence of learning and practice rather than the possible adoption of a liberal criterion.

The inconsistency in the above study's results could also possibly be attributed to the fact that the task was self-paced, a condition which allowed the subject to control his rate of work and so his performance. The subjects may have been able to compensate for momentary lapses and pauses in their accuracy of work by raising their accuracy of work between pauses, thus perhaps inadvertantly giving the above conflicting results. Broadbent (1953b) had stated that no decrement occurred in unpaced tasks .

Saldahna/...

Saldahna (1955) however showed errors to increase over time on such tasks. Kappauf and Payne (1959) studied an observer - paced task which continued for a long duration in a group situation where the subjects, instructed to work as quickly as possible, worked in test booklets. They searched successively for different numbers for an uninterrupted period of 75-minutes during which they were uncertain of the time of "appearance" of the number being sought. Detection rate was found to be high suggesting a small decrement which did occur significantly and which cautioned one against Broadbent's (1953b) generalizations. These findings were similar to those for the present task. Kappauf and Payne (1959) concluded that performance on observerpaced tasks had established the following relation very clearly : in unpaced tasks decline of performance was considerably less evident than that expected from data for similar paced conditions. Also, depending on the specific situation and particular method of evaluating the response latency of subjects, the decline at unpaced tasks may be negligible or slow to appear (Jenkins, 1953 cited by Kappauf and Payne, 1959). The results of the present task agreed.

Extraneous sounds could have an arousing or distracting affect on performance (Mackworth, J.F., 1960). Broadbent (1963) in Buckner and McGrath (1963) suggested that extraneous sounds could either be too stimulating and could lead to the increased tendency to respond to irrelevant stimuli or, if continuous, they were not arousing

and/...

and prevented sounds from providing a variety to the background and so loweringarousal. Mackworth, J.F. (1969) agreed on the latter point. So did Bevan, Avant, and Lankford (1969) who found that a constant sound above the level of the sounds of the test room had no effect upon detection probability in a visual monitoring task. However, adding variable sounds of the same average intensity reliably enhanced performance. The present task used white noise to mask any arousing or distracting sounds the apparatus might have provided. This was successful but it could not mask the sudden banging of doors and sounds in the adjacent passages which could only have served to arouse the subjects and allay decrement. Efforts were made to keep these sounds to a minimum but the only solution would have been to conduct the experiment in a soundproof room which facilities did not provide.

The purpose of the present study was not only to investigate whether decrement occurred but to suggest the use of such results:

All results showed trends in the direction of performance decline. It was therefore hypothesised that should the task have continued for a longer duration useful results might have occurred all round and not with the exception of the average observed pereentage of false reports.

Decrement of performance while driving a motor vehicle occurs with long spells at the wheel.

The/...

The embedded figures principle applies in visual target detection in both driving and in the present task. It is thus possible that results of the present task could be used to construct similar tests with a subject in a simulated driving situation over long task durations. These results could be adapted to ways of maintaining driver alertness, attention to the task, and of reminding drivers of the presence of the factor of performance decrement over time. Similar tests could possibly be constructed for other sensory modalities involved in motoring with the same objective in view.

A further study might find differences between field dependent and independent persons on the present task and in simulated driving situations involving the embedded figures principle.

Finally then, it can be said that the present study achieved what it had set out to do, namely to investigate the hypothesis that vigilance decrement occurs over time in the recognition of embedded figures.

The present study achieved this by demonstrating satisfactory performance data on the number of responses, the average reaction time in seconds, the number of errors, and the percentage of missed signals. The only result not entirely satisfactory was for the percentage of false reports which however did show a trend towards the expected direction.

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# APPENDICES

# APPENDIX 1

## DETAILED RESULTS OF WITKIN'S EFT

The distribution of Time Scores and Means and Standard Deviations for Men and Women from Witkin (1950), Table 1, page 9.

| Total Time Scores | Frequency | |
|---|---|---|
| | Men (N = 51) | Women (N = 51) |
| 0 - 1' 59" | 1 | 0 |
| 2' 0"- 3' 59" | 1 | 2 |
| 4' 0"- 5' 59" | 6 | 2 |
| 6' 0"- 7' 59" | 9 | 7 |
| 8' 0"- 9' 59" | 5 | 1 |
| 10' 0"-11' 59" | 2 | 1 |
| 12' 0"-13' 59" | 5 | 3 |
| 14' 0"-15' 59" | 5 | 2 |
| 16' 0"-17' 59" | 2 | 2 |
| 18' 0"-19' 59" | 3 | 4 |
| 20' 0"-21' 59" | 2 | 5 |
| 22' 0"-23' 59" | 0 | 2 |
| 24' 0"-25' 59" | 2 | 2 |
| 26' 0"-27' 59" | 2 | 3 |
| 28' 0"-29' 59" | 1 | 0 |
| 30' 0"-31' 59" | 0 | 2 |
| 32' 0"-33' 59" | 0 | 2 |
| 34' 0"-35' 59" | 0 | 1 |
| 36' 0"-37' 59" | 1 | 1 |
| 38' 0"-39' 59" | 0 | 2 |
| 40' 0"-41' 59" | 1 | 1 |
| 42' 0"-43' 59" | 0 | 1 |
| 44' 0"-45' 59" | 0 | 0 |

Cont...

The distribution of Time Scores and Means and Standard Deviations in Men and Women from Witkin (1950 , Table 1, Page 9)

| Total Time Scores | Frequency | |
|---|---|---|
| | Men (N = 51) | Women (N = 51) |
| 46' 0" - 47' 59" | 0 | 2 |
| 48' 0" - 49' 59" | 1 | 0 |
| 50' 0" - 51' 59" | 0 | 0 |
| 52' 0" - 53' 59" | 0 | 0 |
| 54' 0" - 55' 59" | 1 | 2 |
| 56' 0" 57' 59" | 0 | 0 |
| 58' 0" - 59' 59" | 1 | 0 |
| . | | |
| . | | |
| . | | |
| . | | |
| 70' 0" - 71' 59" | 0 | 1 |
| Mean | 15' 54" | 23' 18" |
| $\sigma$ | 12' 48" | 15' 12" |

Results for Individual Complex Figures from Witkin (1950), Table 11, page 10.

| Trial No. | Figures | Men (N = 51) | | Women (N = 51) | |
|---|---|---|---|---|---|
| | | Mean Solution time in secs | No. of failures | Mean Solution time in secs. | No. of Failures |
| 1 | A-1 | 62,8 | 3 | 129,9 | 9 |
| 2 | B-1 | 58,1 | 2 | 68,7 | 3 |
| 3 | C-1 | 71,7 | 3 | 99,8 | 8 |
| 4 | D-1 | 59,8 | 2 | 83,2 | 4 |
| 5 | E-1 | 54,9 | 4 | 71,0 | 6 |
| 6 | A-2 | 131,2 | 10 | 156,8 | 11 |
| 7 | F-1 | 12,6 | 0 | 18,3 | 0 |
| 8 | E-2 | 63,9 | 3 | 114,3 | 11 |
| 9 | C-2 | 36,7 | 1 | 66,7 | 4 |
| 10 | G-1 | 10,7 | 0 | 19,8 | 0 |
| 11 | A-3 | 10,3 | 0 | 23,0 | 1 |
| 12 | H-1 | 81,9 | 2 | 151,0 | 14 |
| 13 | E-3 | 39,4 | 1 | 48,4 | 2 |
| 14 | C-3 | 51,2 | 3 | 46,2 | 2 |
| 15 | D-2 | 14,6 | 0 | 18,9 | 1 |
| 16 | G-2 | 27,0 | 0 | 41,1 | 2 |
| 17 | A-4 | 13,4 | 0 | 16,6 | 0 |
| 18 | E-4 | 28,1 | 0 | 48,4 | 4 |
| 19 | B-2 | 17,8 | 0 | 27,6 | 0 |
| 20 | C-4 | 10,7 | 0 | 17,5 | 1 |
| 21 | G-3 | 32,2 | 1 | 24,8 | 0 |
| 22 | A-5 | 23,6 | 0 | 23,9 | 0 |
| 23 | E-5 | 25,5 | 0 | 57,3 | 3 |
| 24 | C-5 | 18,1 | 0 | 23,4 | 2 |

# APPENDIX 2

## DETAILED DESCRIPTION OF

## CIRCUITRY EMPLOYED

## USING THE BRS 300 AND THE 24VDC

## POWER SUPPLIES (FIG. 16)

24 VDC was used throughout all the circuits with the exception of the inputs to change projector slides.

The input modifier and reset unit, CX-103, provided a method of connecting relays, microswitches, and other contact - operated devices into digital network. On the front panel are input jacks for the connection of either normally open (NO) or normally closed (NC) contacts. Operation of the contacts caused the control output to rise from a negative potential (-12V ) to ground (OV) for the duration the contact was held operated. Besides this latter function, the input modifier and reset unit was used to interface the response switches or the 3-minute count out in to the BRS 300 electronic system: 2 wires were fitted to the NO contacts and as soon as these 2 wires were closed (by either the subject pressing one of the response switches, by the 3-minute count being completed, or by the experimenter) the circuit was completed and output rose from - 12V to OV to activate the CX-103. The output at pin 5 of CX-103 activated OS-102 at pin 4 switching it from its stable to its unstable state.

The basic One - Shot adjustable OS - 102 consists of a single input and output and is a monostable circuit. When the input was switched from off to on the OS-102 switched to its unstable state and was triggered into operation at its output for an adjustable time before returning to its stable state. This adjustable time was predetermined. The output at pin 2 was thus a positive pulse of selected width to RY-104 to drive the Carousel Projector 1.

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In addition, the inverted output available at pin 7 was used as a delayed positive pulse at the end of time *t*. This inverted output was the inverse of pin 2. It was thus used to start events at the end of time *t* That is, it was an input to RY - 105 at pin 1 to initiate the vigilance time program by switching the 24 VDC Power Supply through to the 3 timers. The width or delay of the output pulse was determined by the values of a fixed capacitor and front panel mounted potentiometer. An external capacitor of 47 mf was used across pins 3 and 6.

The RY - 104 relay w/drivers consists of 2 dry - reed relays with transistor drivers. Each relay circuit provided one NO contact and was driven by OS - 102. The output relay contacts of RY - 104 were closed while the input terminal was held at ground potential. Thus input 2 from pin 2 of OS - 102 closed the NO contacts which allowed outputs 3 and 4 to operate the Carousel Projector 1 with a short pulse through the heavy duty relay to bring in the next slide. This heavy duty relay was operated by the 24VDC Power Supply. The transient suppression of inductive loads using a capacitor resistor network was necessary for reliable operation.

After the short pulse the inverted output at Pin 7 of OS - 102 was used as an input into RY - 105 at pin 1. The output from RY - 105 pins 3 and 7 switched the 24 VDC Power Supply through to the timers to operate them.

RY/...

RY - 105 (relay w/drivers) consists of 2 mercury wetted relays with transistorized drivers. Each relay circuit provided one Form C contact (normally open, common, normally closed). The RY - 105 may be driven from the output of flip - flops, one - shots, and similar logic units. The relay contacts will remain in their activated state as long as the input terminal is held at ground.

A diode was used across all the timers to draw current off quickly to allow each of the 3 timer's condensor time to discharge after they had timed out 15,10, and 180 -seconds respectively, or till the subject's response, and so start the next cycle. At the end of 15-seconds the first timer's NO contacts closed and the second timer was activated to time out 10-seconds.

When the first timer began timing out 15-seconds the Carousel Projector I's light was switched on by the circuit via its NC contacts. The NO Contacts of the latching relay to this projector were closed because this relay was activated. At the end of 15-seconds the NO contacts in the first timer closed and the first coil of the latching relay was no longer activated and so the light in the Carousel Projector I was switched off. The Carousel Projector II was now activated to flash a slide onto the screen for 10-seconds as timed out by the second timer. This was achieved by the NC contacts of the second timer operating the second coil of the latching relay by closing its NO contacts and so activating the Drinkometer, DO - 101

through/...

through input 3. This Drinkometer from output 6 activated a second One-Shot, OS - 102, through input 4. This provided an input from pin 2 of this OS - 102 into pin 2 of RY - 105. This in turn closed the NO contacts which allowed the outputs 5 and 8 of RY - 105 to operate Carousel Projector II through a heavy duty relay to bring in the next slide. The Drinkometer was designed to be used as a Digibit interface with standard drinking tubes such as the DT - 001 and DT - 002. When the low current path at the sensor is closed the DO - 101 converts the signal into a standard Digibit - type pulse which can be used for logical functions. The high rate of operation ensures the detection of every contact. The second timer, by operating the second coil of the latching relay, also operated a form of delay timing out 3-seconds by closing its NO contacts. After this delay Carousel Projector II's light was switched on.

After the second timer had timed out 10-seconds its NO contacts became closed, and broke the current to the second coil of the latching relay and so switching off Projector II. Current was fed back into the first coil of the latching relay through these closed NO contacts. This switched on the light of Carousel Projector I for 3-minutes. The third timer, activated at the same time, was set for 180-seconds; if no response was made within this time it initiated the resetting of the entire program at CX - 103.

Pins 1 and 2 from the third timer's NO contacts were connected across the response switches. If the subject closed one of these switches or if it was done automatically after 3-minutes, the NO contacts of this timer closed and activated CX-103 to start a new sequence of slides.

There were 2 response switches, each with a double contact. These were called Switch 1 response to "Figure Yes" and Switch 2 response to "Figure No". There were also 3 pens used on the Three-Pen Recorder: Pen 1 registered the change of each slide, Pen 2 registered response to "Figure Yes" and Pen 3 registered response to "Figure No". Switch 1 was in parralled to the output of the third timer and, when depressed, reset the program as would timer 3 at the end of $t$; it also supplied voltage to Pen 2 of the Three-Pen Recorder. When the program was reset the output 2 of the first OS - 102 also operated RY - 105's outputs 8 and 5 through input 2 to switch voltage through to Pen 1. Switch 2 was also in parallel with the output of the third timer and, when depressed, also reset the program and supplied voltage to Pen 3.

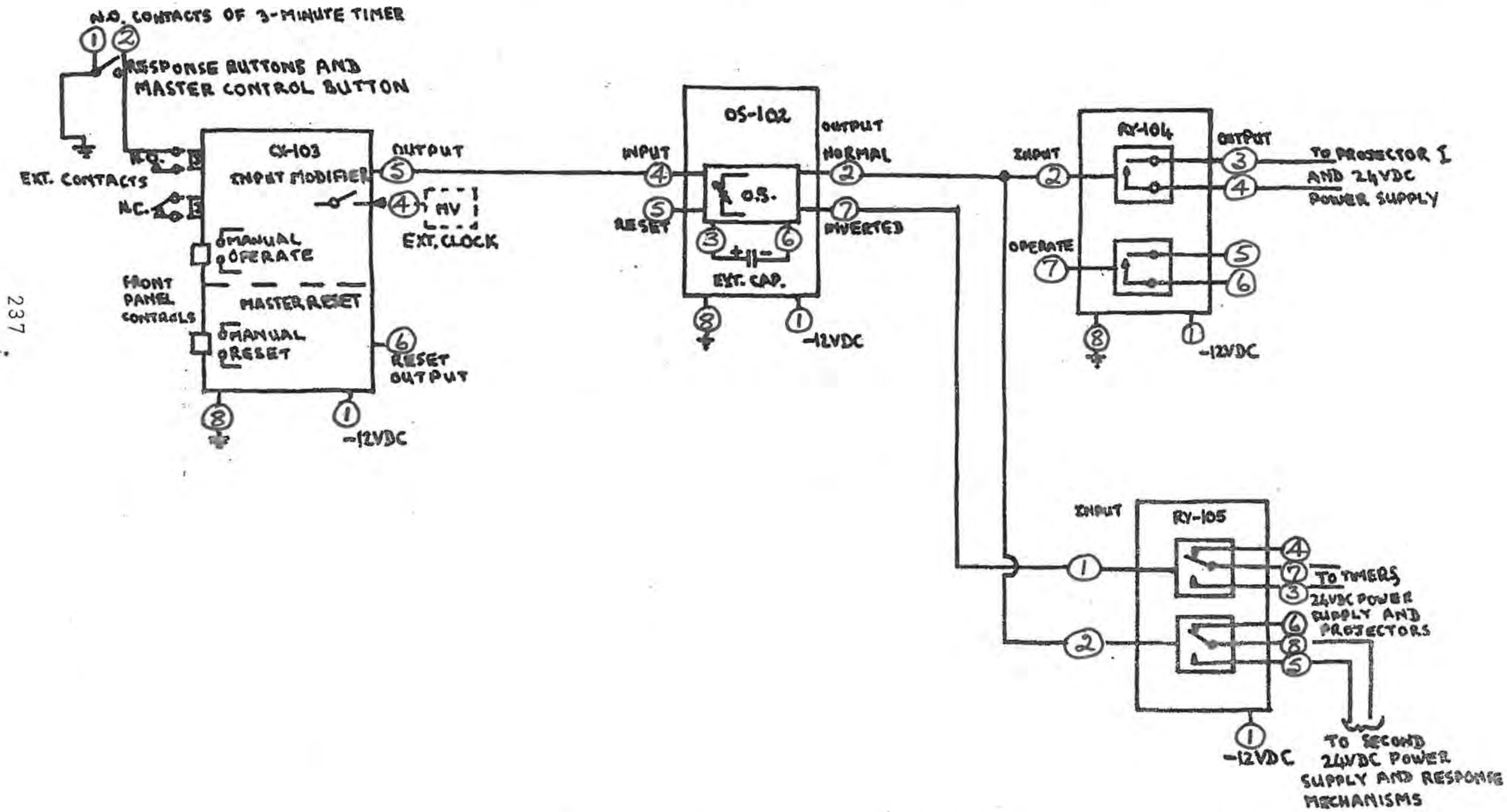


Fig. 16 Diagram of Circuitry Initially Employed Using the BRS 300 and the 24 VDC Power Supplies

Cont...

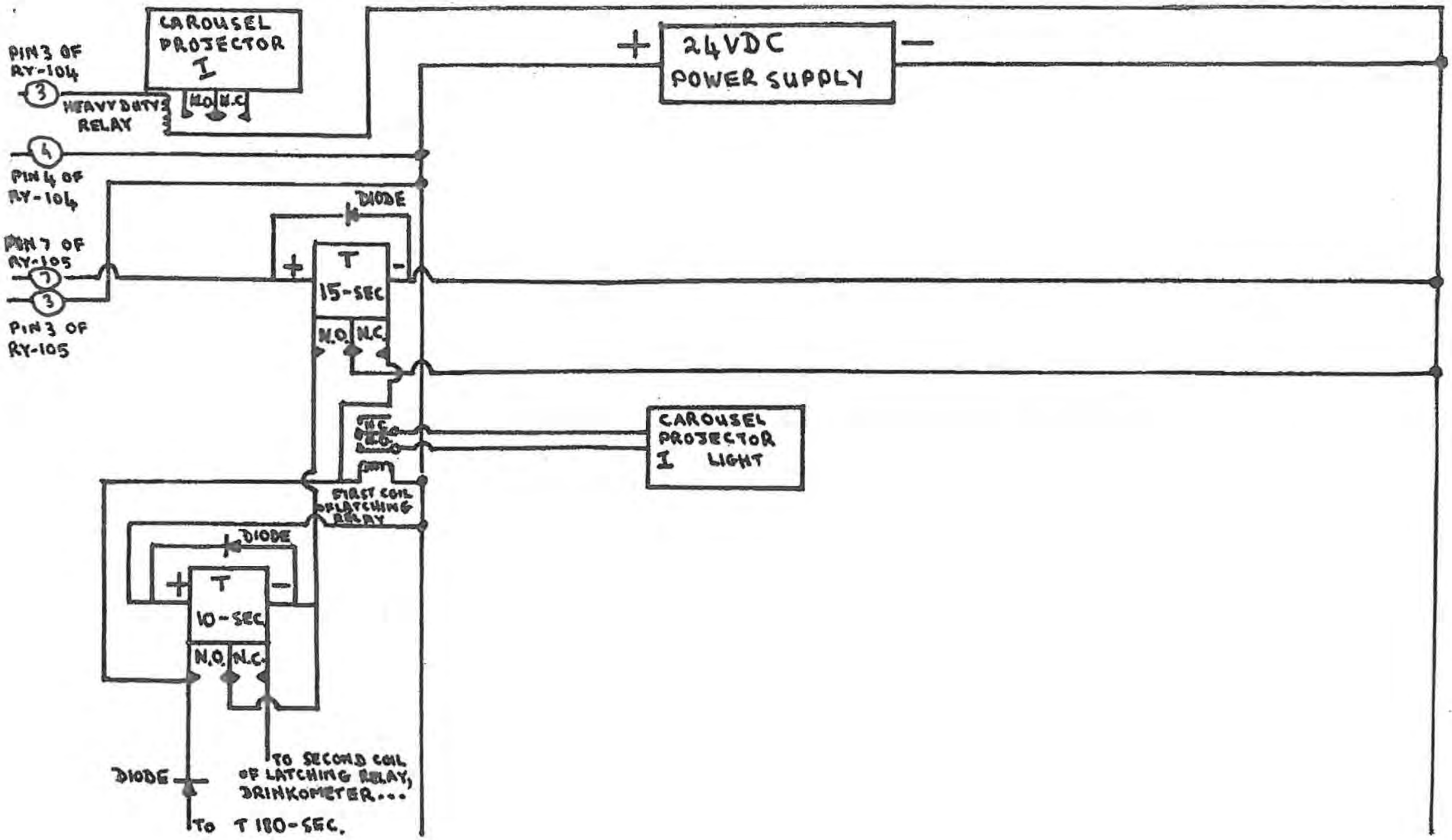


Fig.16 Diagram of Circuitry Initially Employed Using BRS 300 and the 24 VDC Power Supplies

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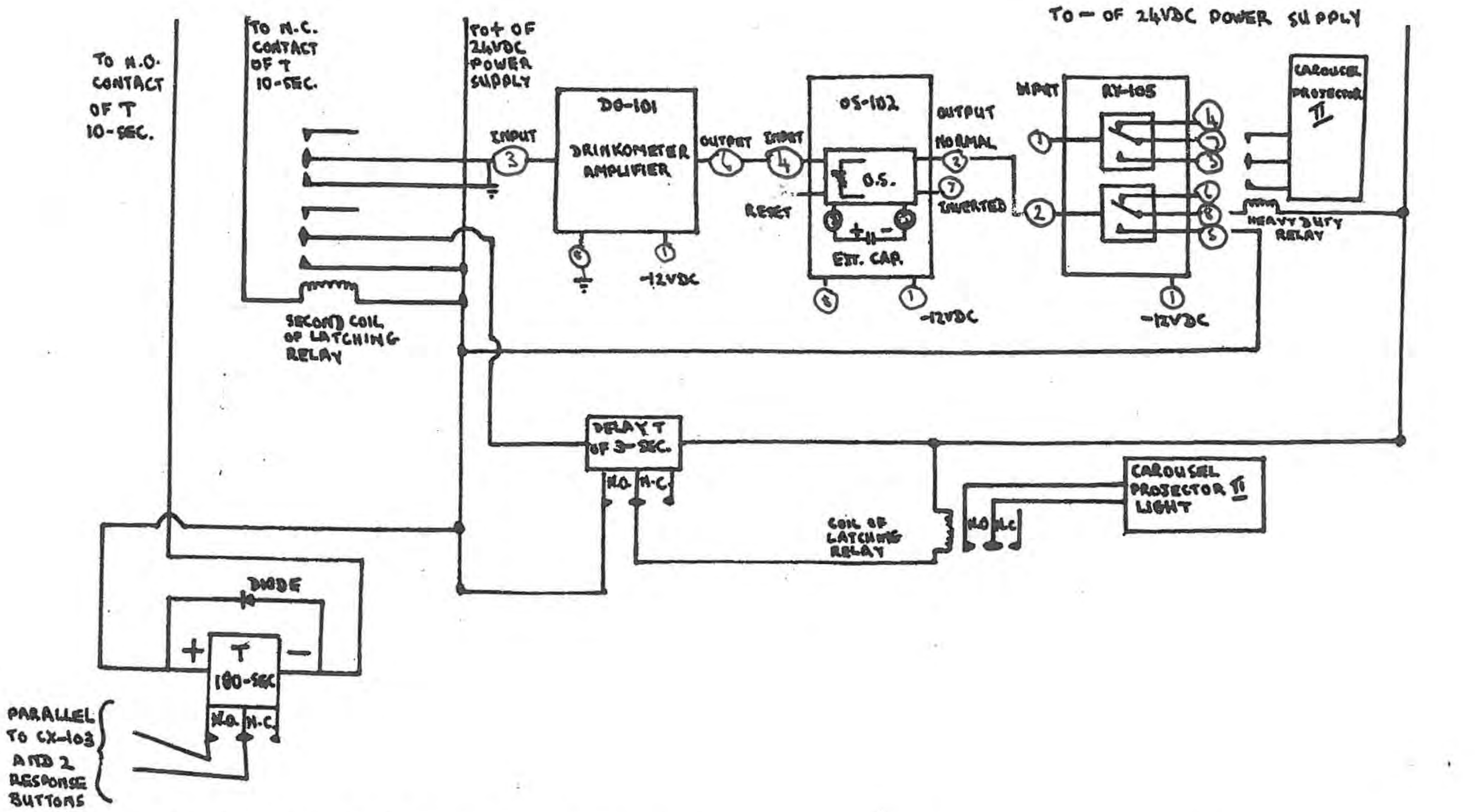



Fig. 16 Diagram of Circuitry Initially Employed Using the BRS 300 and the 24 VDC Power Supplies

Cont...

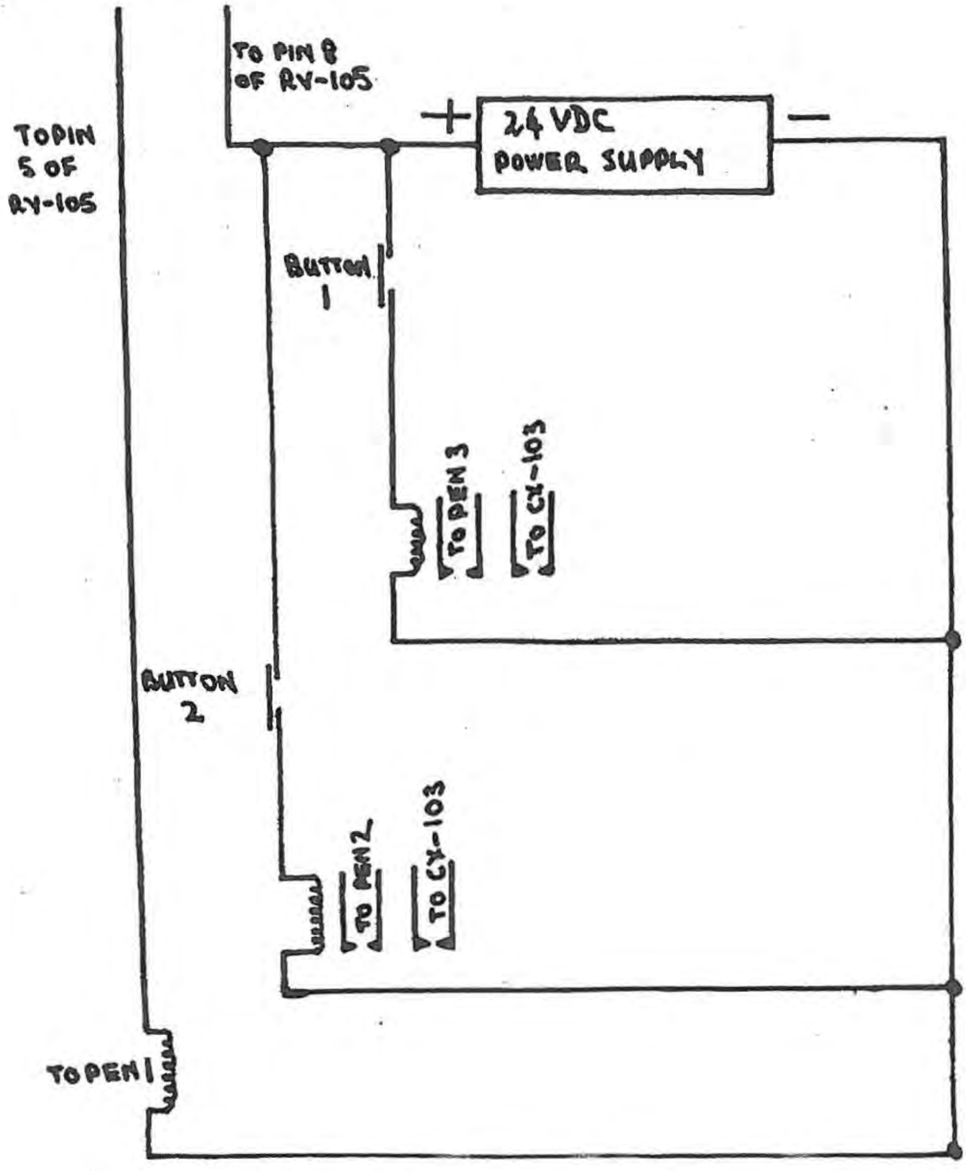



Fig. 16 Diagram of Circuitry Employed Using the BRS 300
and the 24 VDC Power Supplies

# APPENDIX 3

## DETAILED DESCRIPTION OF CIRCUITRY EMPLOYED USING THE BRS 300 AND THE 24VDC POWER SUPPLIES (FIG. 17)

24 VDC was used throughout all the circuits with the exception of the inputs to change projector slides.

The input modifier and reset unit, CX - 103, provided a method of connecting relays, microswitches, and other contact - operated devices into digital network. On the front panel are input jacks for the connection of either normally open (NO) or normally closed (NC) contacts. Operation of these contacts caused the control output to rise from a negative potential (-12V) to ground (OV) for the duration the contact was held operated. Besides this latter function, the input modifier and reset unit was used to interface the response switches or the 3-minute count out into the BRS 300 electronic system: 2 wires were fitted to the NO contacts and as soon as these 2 wires were closed (by either the subject pressing one of the response switches, by the 3-minute count being completed, or by the experimenter) the circuit was completed and output rose from - 12V to OV to activate CX-103. The output at pin 5 of CX - 103 activated OS - 102 at pin 4 switching it from its stable to its unstable state.

The basic one - shot adjustable, OS - 102, consists of a single input and output and is a monostable circuit. When the input was switched from off to on the OS-102 switched to its unstable state and was triggered into operation at its output for an adjustable time, before returning to its stable state. This adjustable time was predetermined.

The/...

The output at pin 2 was thus a positive pulse of selected width to two RY - 105 relay w/drivers, to one at input 2 and to both at input 1 to move on each Carousal S Projector via outputs 7 and 3 of each RY-105. This was achieved through each projector's heavy duty relay operated by one 24 VDC Power Supply. The other output from pin 2 of OS-102 was a positive pulse of selected width to input 2 of one RY - 105 to switch, through outputs 8 and 5, the other 24 VDC power supply through to 3 pens of a Three Pen Recorder. The inverted output at pin 7 of OS - 102 which was the inverse of the output at pin 2 was used as a delayed positive input pulse at the end of time $t$ to input 2 of the RY - 105 not operating the 3 pens. This initiated the vigilance time program through outputs 8 and 5 by switching the 24 VDC Power Supply operating the projectors' heavy duty relays through to 2 timers.

RY - 105 relay w/drivers consists of 2 mercury wetted relays with transistorized drivers. Each relay circuit provided one Form C contact (normally open, common, normally closed). The RY - 105 may be driven from the output of flip-flops, one - shots and similar logic units. The relay contacts will remain in their activated state as long as the input terminal is held at ground.

A diode was used across all the timers to draw current off quickly to allow the 2 timers' condensors time to

discharge/...

discharge after they had timed out 10 and 180-seconds respectively, or till the subject's response, and so start the next sequence of slides. Thus at the end of 10-seconds the NO contacts of the first timer closed and the second timer was activated to time out 180-seconds.

When the first timer began timing out 10-seconds the Carousel Projector I's light was switched on by the circuit through its NO contact which closed because the second coil of the latching relay was activated. At the end of 10-seconds the NO contacts in the first timer closed, the second coil of the latching relay was no longer activated, and the NO contacts above this relay opened and so Carousel Projector I's light was switched off. The light of Carousel Projector II was now switched on for a maximum of 180 - seconds by the NC contacts of the second timer which operated the first coil of the latching relay by closing NO contacts above it. After the second timer had timed out 180-seconds or after the subject had responded this timer's NO contacts closed. This switched off the second projector's light as the first coil of the latching relay was no longer activated and the NO contacts above it opened. This also initiated the next program at CX - 103 by allowing the NC contacts above the first coil of the latching relay to close.

Pins 1 and 2 from the NC contacts above the NO contacts of the first coil of the latching relay were connected across the response switches. If the subject closed one of these switches, or if it was done automatically after 180 - seconds, these NC contacts above the NO contacts of the first coil of the latching relay closed and activated the CX - 103 to start the next sequence of slides.

There were 2 response switches, each with a double contact. These were called Switch 1 response to "Figure Yes" and Switch 2 response to "Figure NO". There were also 3 pens used on the Three - Pen Recorder. Pen 1 registered change of each slide, Pen 2 registered response to "Figure Yes" and Pen 3 registered response to "Figure NO". Switch 1 was in parallel to the output of the second timer and, when depressed, reset the program as would timer 2 at the end of time t; it also supplied voltage to Pen 2 of the Three-Pen Recorder. When the program was reset the output 2 of OS - 102 operated one RY - 105's outputs 8 and 5 through input 2 to switch voltage through to Pen 1. Switch 2 was in parrallel with the output of the second timer and, when depressed, also reset the program and supplied voltage to Pen 3.

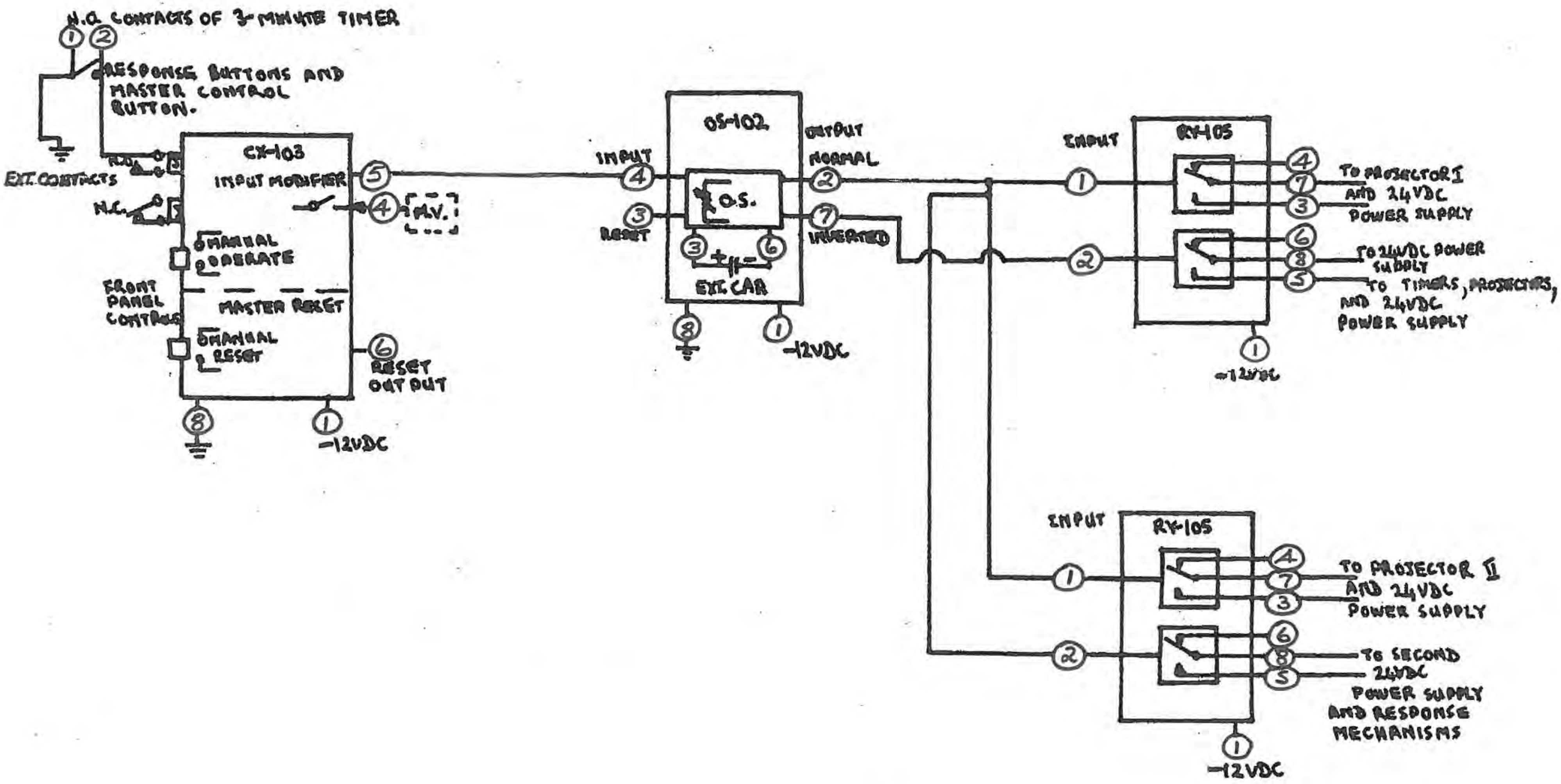



Fig. 17 Diagram of Circuitry Employed Using the BRS 300 and the 24 VDC Power Supplies

Cont....

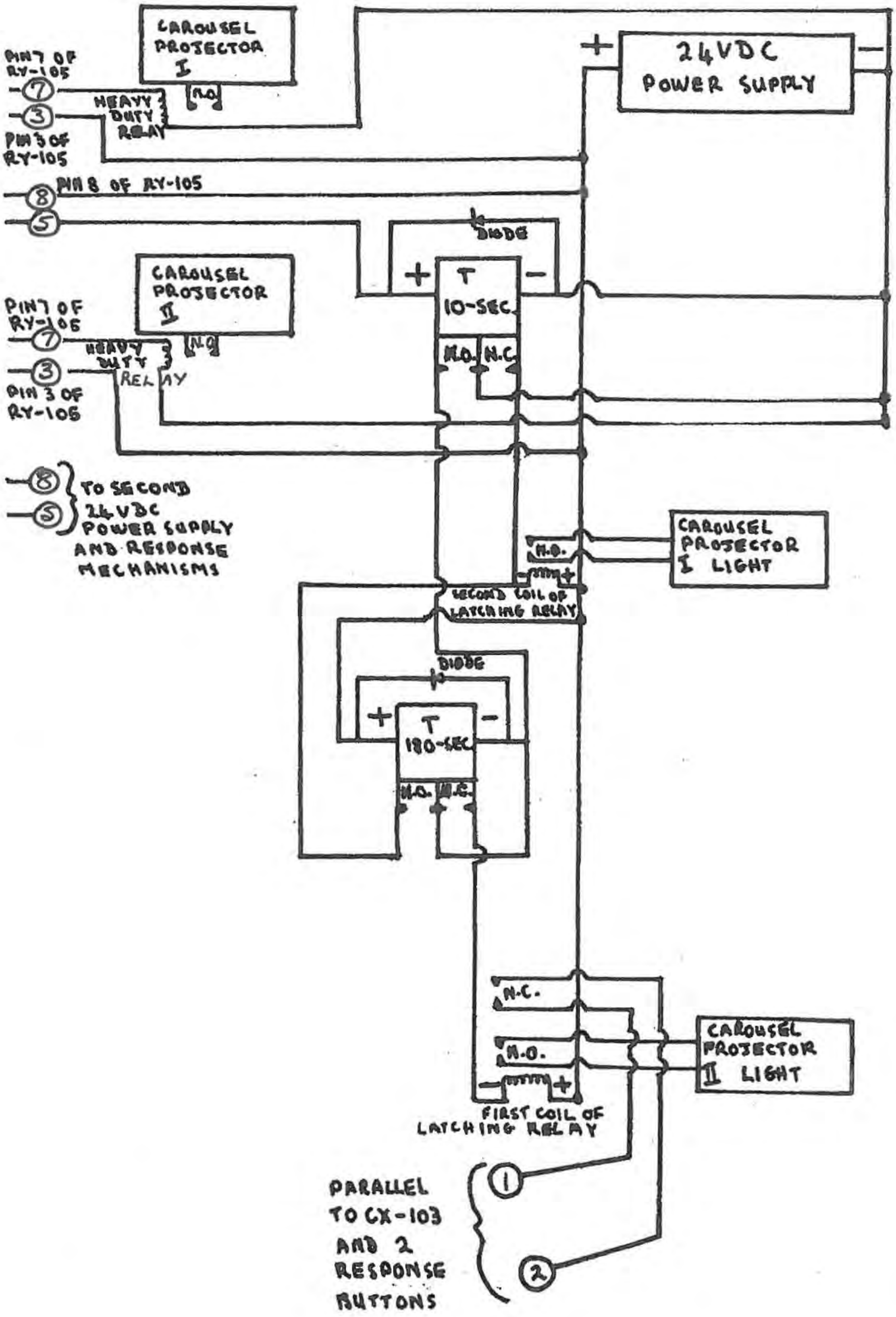



Fig. 17 Diagram of Circuitry Employed Using the BRS 300 and the 24 VDC Power Supplies

Cont...

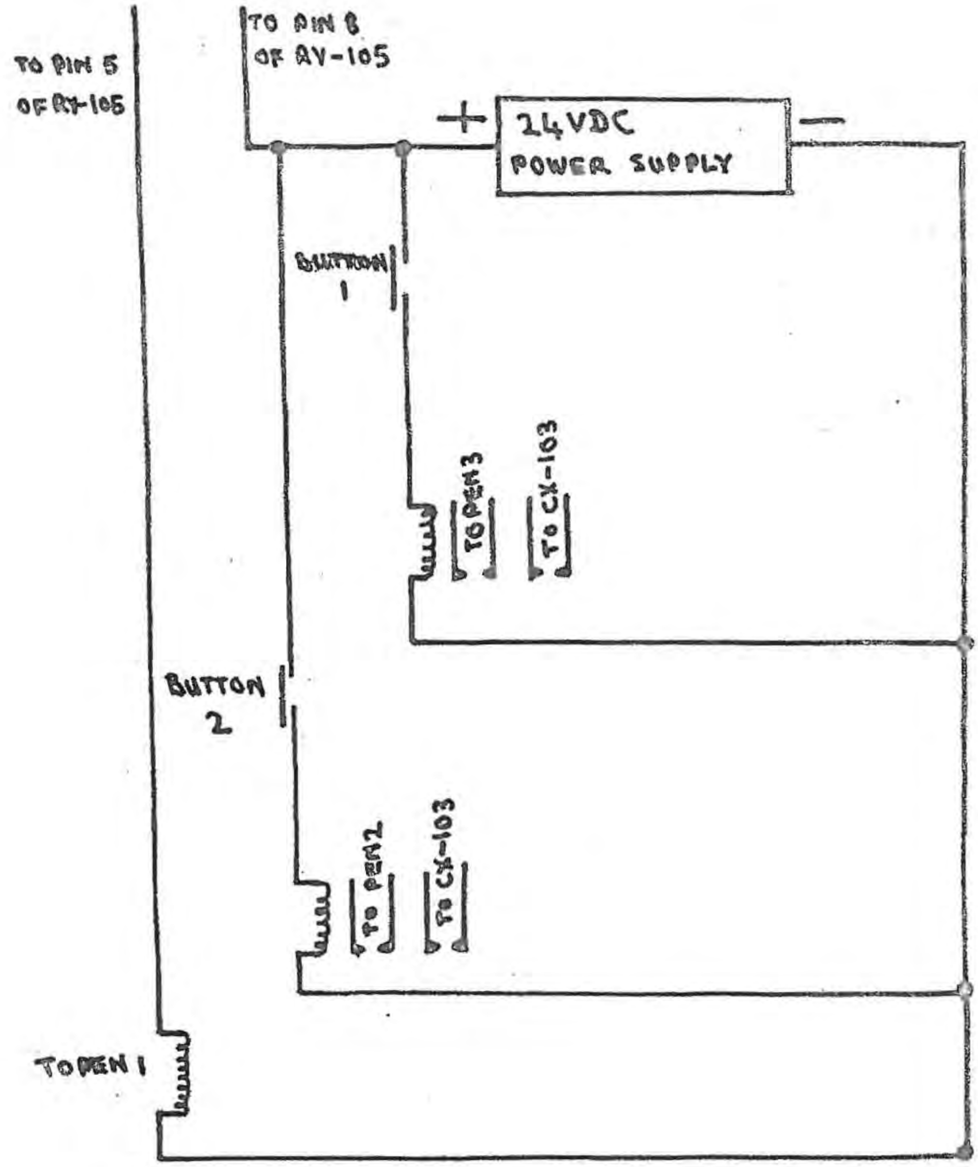



Fig. 17 Diagram of Circuitry Employed Using the BRS 300 and the 24 VDC Power Supplies

APPENDIX 4

ANALYSIS OF THE AVERAGE NUMBER OF RESPONSES FOR 30 SUBJECTS

$$r = \frac{\left[n \sum t_i y_i - (\sum t_i)(\sum y_i)\right]}{\sqrt{\left[n \sum t_i^2 - (\sum t_i)^2\right]\left[n \sum y_i^2 - (\sum y_i)^2\right]}}$$

$$= \frac{\left[(8 \times 381,30) - (9)(326,07)\right]}{\sqrt{\left[8 \times 12,75 - (9)^2\right]\left[8 \times 13369,22 - (326,07)^2\right]}}$$

$$= \frac{\left[3050,40 - 2934,63\right]}{\sqrt{\left[102,00 - 81\right]\left[106953,76 - 106321,64\right]}}$$

$$= \frac{113,37}{\sqrt{21 \times 632,12}}$$

$$= \frac{113,37}{\sqrt{13274,52}}$$

$$= \frac{113,37}{115,22}$$

$$= 0,9839437$$

$$b_y = \frac{[A]}{[B]}$$

$$b_y = \frac{\left[ n \sum t_i y_i - (\sum t_i)(\sum y_i) \right]}{\left[ n \sum t_i^2 - (\sum t_i)^2 \right]}$$

$$= \frac{113,37}{21,00}$$

$$= 5,40$$

1. $ye = b_y t + (\overline{y} - \overline{t}\ b_y)$

$= 5,40 \times 0,25 + (40,76 - 1,13 \times 5,51)$

$= 1,35 + (40,76 - 6,23)$

$= 1,35 + 34,53$

$= 35,88$

2. $ye = b_y t + (\overline{y} - \overline{t}\ b_y)$

$= 5,40 \times 0,50 + (34,53)$

$= 2,70 + 34,53$

$= 37,23$

3. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= 5{,}40 \times 0{,}75 + (34{,}53)$

$= 4{,}05 + 34{,}53$

$= 38{,}58$

4. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= 5{,}40 \times 1 + (34{,}53)$

$= 5{,}40 + 34{,}53$

$= 39{,}93$

5. $ye = b_y t + (\overline{y} - \overline{t}\ b_y)$

$= 5{,}40 \times 1{,}25 + (34{,}53)$

$= 6{,}75 + 34{,}53$

$= 41{,}28$

6. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= 5{,}40 \times 1{,}50 + (34{,}53)$

$= 8{,}10 + 34{,}53$

$= 42{,}63$

7. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= 5{,}40 \times 1{,}75 + (34{,}53)$

$= 9{,}45 + 34{,}53$

$= 43{,}98$

8. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= 5{,}40 \times 2 + (34{,}53)$

$= 10{,}80 + 34{,}53$

$= 45{,}33$

Standard error in the estimate of $y$ :

$$s_y = s_y \sqrt{1 - r^2}$$

where

$$s_y = \frac{\sum y^2}{n} - \bar{y}^2$$

$$= \frac{13369,22}{8} - 1661,38$$

$$= 1671,15 - 1661,38$$

$$= 9,77$$

$$s_y = s_y \sqrt{1 - r^2}$$

$$= 9,77 \sqrt{1 - (0,9839437)^2}$$

$$= 9,77 \sqrt{1 - (0,97)}$$

$$= 9,77 \sqrt{0,03}$$

$$= 9,77 \times 0,1730$$

$$= 1,66$$

Table 41 for $S_y$ = 1,66

| Observed Results $\overline{y}o$ | Estimated Results $\overline{y}e$ | Estimated Results -( ) $S_y$ | Estimated Results +( ) $S_y$ |
|---|---|---|---|
| 36,67 | 35,88 | $\overline{y}e - 1 S_y$ = 34,22 | $\overline{y}e + 1 S_y$ = 37,54 |
| 37,93 | 37,23 | $\overline{y}e - 1 S_y$ = 35,57 | $\overline{y}e + 1 S_y$ = 38,89 |
| 37,63 | 38,58 | $\overline{y}e - 1 S_y$ = 36,92 | $\overline{y}e + 1 S_y$ = 40,24 |
| 39,53 | 39,93 | $\overline{y}e - 1 S_y$ = 38,27 | $\overline{y}e + 1 S_y$ = 41,59 |
| 41,40 | 41,28 | $\overline{y}e - 1 S_y$ = 39,62 | $\overline{y}e + 1 S_y$ = 42,94 |
| 42,57 | 42,63 | $\overline{y}e - 1 S_y$ = 40,97 | $\overline{y}e + 1 S_y$ = 44,29 |
| 44,47 | 43,98 | $\overline{y}e - 1 S_y$ = 42,32 | $\overline{y}e + 1 S_y$ = 45,64 |
| 45,83 | 45,33 | $\overline{y}e - 1 S_y$ = 43,67 | $\overline{y}e + 1 S_y$ = 46,99 |

$$\chi^2 = \sum \frac{(fo - fe)^2}{fe}$$

| Frequencies | | | | | |
|---|---|---|---|---|---|
| Grades | $fo$ | $fe$ | $(fo-fe)$ | $(fo-fe)^2$ | $\frac{(fo-fe)^2}{fe}$ |
| ¼ | 36,67 | 35,88 | 0,79 | 0,62 | 0,02 |
| ½ | 37,93 | 37,23 | 0,70 | 0,49 | 0,01 |
| ¾ | 37,63 | 38,58 | 0,95 | 0,90 | 0,02 |
| 1 | 39,53 | 39,93 | 0,40 | 0,16 | 0,00 |
| 1¼ | 41,40 | 41,28 | 0,12 | 0,01 | 0,00 |
| 1½ | 42,57 | 42,63 | 0,06 | 0,00 | 0,00 |
| 1¾ | 44,47 | 43,98 | 0,49 | 0,24 | 0,01 |
| 2 | 45,83 | 45,33 | 0,50 | 0,25 | 0,01 |
| TOTAL | | | | $\chi^2$ | 0,07 |

$$d.f. = n - 1$$
$$= 8 - 1$$
$$= 7$$

# APPENDIX 5

## ANALYSIS OF THE AVERAGE REACTION TIME

## IN SECONDS FOR 30 SUBJECTS

$$r = \frac{\left[ n \sum t_i y_i - \left( \sum t_i \right) \left( \sum y_i \right) \right]}{\sqrt{\left[ n \sum t_i^2 - \left( \sum t_i \right)^2 \right] \left[ n \ y_i^2 - \left( \sum y_i \right)^2 \right]}}$$

$$= \frac{\left[ (8 \times 212{,}56) - (9)\ (197{,}47) \right]}{\sqrt{\left[ 8 \times 12{,}75 - (9)^2 \right] \left[ 8 \times 4913{,}46 - (197{,}44)^2 \right]}}$$

$$= \frac{\left[ 1700{,}48 - 1777{,}23 \right]}{\sqrt{\left[ 102{,}00 - 81 \right] \left[ 39307{,}68 - 38982{,}55 \right]}}$$

$$= \frac{-76{,}75}{\sqrt{21 \times 325{,}13}}$$

$$= \frac{-76{,}75}{\sqrt{6827{,}73}}$$

$$= \frac{-76{,}75}{82{,}63}$$

$$= -0{,}9274924$$

$$b_y = \frac{[A]}{[B]}$$

$$= \frac{[n\sum t_i y_i - (\sum t_i)(\sum y_i)]}{[n\sum t_i^2 - (\sum t_i)^2]}$$

$$= -\frac{76,75}{21}$$

$$= - \quad 3,65$$

1\. $ye = b_y t + (\overline{y} - \overline{t}\, b_y)$

$= -3,65 \times 0,25 + [24,68 - (1,13 \times -3\ 65)]$

$= -0,91 + [24,68 - (14,12)]$

$= -0,91 + 28,80$

$= 27,89$

2\. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= -3,65 \times 0,50 + 28,80$

$= -1,83 + 28,80$

$= 26,97$

$$3.\ ye = b_y t + (\overline{y} - \overline{t}\ b_y)$$

$$= -\ 3{,}65 \times 0{,}75 + 28{,}80$$

$$= -\ 2{,}74 + 28{,}80$$

$$= 26{,}06$$

$$4.\ ye = b_y t + (\overline{y} - \overline{t}\ b_y)$$

$$= -\ 3{,}65 \times 1 + 28{,}80$$

$$= -\ 3{,}65 + 28{,}80$$

$$= 25{,}15$$

$$5.\ ye = b_y t + (\overline{y} - \overline{t} b_y)$$

$$= -\ 3{,}65 \times 1{,}25 + 28{,}80$$

$$= -\ 4{,}56 + 28{,}80$$

$$= 24{,}24$$

6. $ye = b_3 t + (\overline{y} - \overline{t}\ b_3)$

$= -\ 3,65 \times 1,50 + 28,80$

$= -\ 5,48 + 28,80$

$= 23,32$

7. $ye = b_3 t + (\overline{y} - \overline{t}\ b_3)$

$= -\ 3,65 \times 1,75 + 28,80$

$= -\ 6,39 + 28,80$

$= 22,41$

8. $ye = b_3 t + (\overline{y} - \overline{t} b_3)$

$= -\ 3,65 \times 2 + 28,80$

$= -\ 7,30 + 28,80$

$= 21,50$

Standard error in the estimate $y$ :

$$Sy = s_y \sqrt{1 - r^2}$$

where

$$s_y = \frac{\Sigma y^2}{n} - \bar{y}^2$$

$$= \frac{4913,46}{8} - 609,10$$

$$= 614,18 - 609,10$$

$$= 5,08$$

$$Sy = s_y \sqrt{1 - r^2}$$

$$= 5,08 \sqrt{1 - (-0,9274924)^2}$$

$$= 5,08 \sqrt{1 - 0,86}$$

$$= 5,08 \sqrt{0,14}$$

$$= 5,08 \times 0,37$$

$$= 1,90$$

Table 42 for $Sy$ = 1,90

| Observed Results $\bar{y}o$ | Estimated Results $\bar{y}e$ | Estimated Results $-$ (   ) $Sy$ | Estimated Results $+$ (   ) $Sy$ |
|---|---|---|---|
| 27,11 | 27,89 | $\bar{y}e - 1\,Sy$ =25,98 | $\bar{y}e + 1\,Sy$ = 29,79 |
| 26,39 | 26,97 | $\bar{y}e - 1\,Sy$ =25,07 | $\bar{y}e + 1\,Sy$ = 28,87 |
| 26,67 | 26,06 | $\bar{y}e - 1\,Sy$ =24,16 | $\bar{y}e + 1\,Sy$ = 27,96 |
| 26,68 | 25,15 | $\bar{y}e - 1\,Sy$ =23,25 | $\bar{y}e + 1\,Sy$ = 27,05 |
| 24,24 | 24,24 | $\bar{y}e - 1\,Sy$ =23,34 | $\bar{y}e + 1\,Sy$ = 26,14 |
| 23,36 | 23,32 | $\bar{y}e - 1\,Sy$ =21,42 | $\bar{y}e + 1\,Sy$ = 25,22 |
| 21,92 | 22,41 | $\bar{y}e - 1\,Sy$ =20,51 | $\bar{y}e + 1\,Sy$ = 24,31 |
| 21,10 | 21,50 | $\bar{y}e - 1\,Sy$ =19,60 | $\bar{y}e + 1\,Sy$ = 23,40 |

$$\chi^2 = \sum \frac{(fo - fe)^2}{fe}$$

| Frequencies | | | | | |
|---|---|---|---|---|---|
| Grades | $fo$ | $fe$ | $(fo - fe)$ | $(fo - fe)^2$ | $\frac{(fo-fe)^2}{fe}$ |
| ¼ | 27,11 | 27,89 | - 0,78 | 0,61 | 0,02 |
| ½ | 26,39 | 26;97 | - 0,58 | 0,34 | 0,01 |
| ¾ | 26,67 | 26,06 | 0,61 | 0,37 | 0,01 |
| 1 | 26,68 | 25,15 | 1,53 | 2,34 | 0,09 |
| 1¼ | 24,24 | 24,24 | 0,00 | 0,00 | 0,00 |
| 1½ | 23,36 | 23,32 | 0,04 | 0,00 | 0,00 |
| 1¾ | 21,92 | 22,41 | 0,49 | 0,24 | 0,01 |
| 2 | 21,10 | 21,50 | 0,40 | 0,26 | 0,01 |
| TOTAL | | | | $\chi^2$ | 0,15 |

# APPENDIX 6

## ANALYSIS OF THE AVERAGE NUMBER OF ERRORS FOR 30 SUBJECTS

$$r = \frac{\left[ n \sum t_i y_i - (\sum t_i)(\sum y_i) \right]}{\sqrt{\left[ n \sum t_i^2 - (\sum t_i)^2 \right] \left[ n \sum y_i^2 - (\sum y_i)^2 \right]}}$$

$$= \frac{\left[ 8 \times 78{,}86 - (9)\ (69{,}43) \right]}{\sqrt{\left[ 8 \times 12{,}75 - (9)^2 \right] \left[ 8 \times 612{,}94 - (69{,}43)^2 \right]}}$$

$$= \frac{\left[ 630{,}88 - 624{,}87 \right]}{\sqrt{\left[ 102{,}00 - 81 \right] \left[ 4903{,}52 - 4820{,}52 \right]}}$$

$$= \frac{6{,}01}{\sqrt{21 \times 83}}$$

$$= \frac{6{,}01}{\sqrt{1743}}$$

$$= \frac{6{,}01}{47{,}75}$$

$$= 0{,}1439520$$

$$b_1 = \frac{[A]}{[B]}$$

$$= \frac{[n \sum t_i y_i - (\sum t_i)(\sum y_i)]}{[n \sum t_i^2 - (\sum t_i)^2]}$$

$$= \frac{6,01}{21}$$

$$= 0,29$$

1. $ye = b_y t + (\bar{y} - \bar{t}\, b_y)$

$= 0,29 \times 0,25 + (8,68 - 1,13 \times 0,29)$

$= 0,07 + 8,35$

$= 8,42$

2. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 0,29 \times 0,50 + (8,35)$

$= 0,15 + 8,35$

$= 8,50$

3. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 0,29 \times 0,75 + (8,35)$

$= 0,22 + 8,35$

$= 8,57$

4. $ye = b_1 t + (\bar{y} - \bar{t} b_y)$

$= 0,29 \times 1 + 8,35$

$= 0,29 + 8,35$

$= 8,64$

5. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 0,29 \times 1,25 + 8,35$

$= 0,36 + 8,35$

$= 8,71$

6. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= 0,29 \times 1,50 + 8,35$

$= 0,44 + 8,35$

$= 8,79$

7. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= 0,29 \times 1,75 + 8,35$

$= 0,51 + 8,35$

$= 8,86$

8. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= 0,29 \times 2 + 8,35$

$= 0,58 + 8,35$

$= 8,93$

Standard error in the estimate of $y$:

$$S_y = s_y \sqrt{1 - r^2}$$

where

$$s_y = \frac{\sum y^2}{n} - \bar{y}^2$$

$$= \frac{612,94}{8} - 75,34$$

$$= 76,62 - 75,34$$

$$= 1,28$$

$$S_y = s_y \sqrt{1 - r^2}$$

$$= 1,28 \sqrt{1 - (0,1439520)^2}$$

$$= 1,28 \sqrt{1 - 0,02}$$

$$= 1,28 \sqrt{0,97994}$$

$$= 1,28 \times 0,98$$

$$= 1,27$$

Table 43 for $S_y$ = 1,27

| Observed Results $\overline{y}o$ | Estimated Results $\overline{y}e$ | Estimated Results − ( ) $S_y$ | Estimated Results + ( ) $S_y$ |
|---|---|---|---|
| 10,60 | 8,42 | $\overline{y}e - 2S_y = 5,88$ | $\overline{y}e + 2S_y = 10,96$ |
| 8,00 | 8,50 | $\overline{y}e - 1S_y = 7,23$ | $\overline{y}e + 1S_y = 9,77$ |
| 7,60 | 8,57 | $\overline{y}e - 1S_y = 7,30$ | $\overline{y}e + 1S_y = 9,84$ |
| 7,63 | 8,64 | $\overline{y}e - 1S_y = 7,37$ | $\overline{y}e + 1S_y = 9,91$ |
| 7,93 | 8,71 | $\overline{y}e - 1S_y = 7,44$ | $\overline{y}e + 1S_y = 9,98$ |
| 8,00 | 8,79 | $\overline{y}e - 1S_y = 7,52$ | $\overline{y}e + 1S_y = 10,06$ |
| 9,47 | 8,86 | $\overline{y}e - 1S_y = 7,59$ | $\overline{y}e + 1S_y = 10,13$ |
| 10,20 | 8,93 | $\overline{y}e - 1S_y = 7,66$ | $\overline{y}e + 1S_y = 10,20$ |

$$\chi^2 = \sum \frac{(fo - fe)^2}{fe}$$

| Frequencies | | | | | |
|---|---|---|---|---|---|
| Grades | $fo$ | $fe$ | $(fo - fe)$ | $(fo - fe)^2$ | $\frac{(fo - fe)^2}{fe}$ |
| ¼ | 10,60 | 8,42 | 2,18 | 4,75 | 0,56 |
| ½ | 8,00 | 8,50 | - 0,50 | 0,25 | 0,03 |
| ¾ | 7,60 | 8,57 | - 0,97 | 0,94 | 0,11 |
| 1 | 7,63 | 8,64 | - 1,01 | 1,01 | 0,12 |
| 1¼ | 7,93 | 8,71 | - 0,78 | 0,61 | 0,07 |
| 1½ | 8,00 | 8,79 | - 0,79 | 0,62 | 0,07 |
| 1¾ | 9,47 | 8,86 | 0,61 | 0,37 | 0,04 |
| 2 | 10,20 | 8,93 | 1,27 | 1,61 | 0,18 |
| TOTAL | | | | $\chi^2$ | 1,18 |

$$d.f. = n - 1$$
$$= 8 - 1$$
$$= 7$$

# APPENDIX 7

## ANALYSIS OF THE AVERAGE PERCENTAGE OF FALSE REPORTS FOR 30 SUBJECTS

$$r = \frac{[n \sum t_i y_i - (\sum t_i)(\sum y_i)]}{\sqrt{[n \sum t_i^2 - (\sum t_i)^2][n \sum y_i^2 - (\sum y_i)^2]}}$$

$$= \frac{[8 \times 135,97 \times (9)(155,21)]}{\sqrt{[8 \times 12,75 - (9)^2][8 \times 2024,10 - (155,21)^2]}}$$

$$= \frac{[1087,76 - 1036,89]}{\sqrt{[102,00 - 81][16192,80 - 13273,34]}}$$

$$= \frac{50,87}{\sqrt{21 \times 2919,46}}$$

$$= \frac{50,87}{\sqrt{61308,66}}$$

$$= \frac{50,87}{247,60}$$

$$= 0,2054523$$

$$by = \frac{[A]}{[B]}$$

$$= \frac{[n \sum t_i y_i - (\sum t_i)(\sum y_i)]}{\sqrt{[n \sum t_i^2 - (\sum t_i)^2]}}$$

$$= \frac{50,87}{21}$$

$$= 2,42$$

1. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 2,42 \times 0,25 + (14,40 - 1,13 \times 2,42)$

$= 0,61 + (14,40 - 2,73)$

$= 0,61 + 11,67$

$= 12,28$

2. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 2,42 \times 0,50 + 11,67$

$= 1,21 + 11,67$

$= 12,88$

3. $ye = b_{y}t + (\overline{y} - \overline{t}b_{y}')$

$= 2,42 \times 0,75 + 11,67$

$= 1,82 + 11,67$

$= 13,49$

4. $ye = b_{y}t + (\overline{y} - \overline{t}\ b_{y}')$

$= 2,42 \times 1 + 11,67$

$= 2,42 + 11,67$

$= 14,09$

5. $ye = b_{y}t + (\overline{y} - \overline{t}b_{y}')$

$= 2,42 \times 1,25 + 11,67$

$= 3,03 + 11,67$

$= 14,70$

6. $ye = b_y t + (\bar{y} - \bar{t}b_y)$

$= 2,42 \times 1,50 + 11,67$

$= 3,63 + 11,67$

$= 15,30$

7. $ye = b_y t + (\bar{y} - \bar{t}b_y)$

$= 2,42 \times 1,75 + 11,67$

$= 4,24 + 11,67$

$= 15,91$

8. $ye = b_y t + (\bar{y} - \bar{t}b_y)$

$= 2,42 \times 2 + 11,67$

$= 4,84 + 11,67$

$= 16,51$

Standard error in the estimate of $y$ :

$$S_y \quad s_y\sqrt{1 - r^2}$$

where

$$s_y = \frac{\sum y^2}{n} - \bar{y}^2$$

$$= \frac{2024,10}{8} - 207,36$$

$$= 253,01 - 207,36$$

$$= 45,65$$

$$S_y = s_y \sqrt{1 - r^2}$$

$$= 45,65 \sqrt{1 - (0,2054523)^2}$$

$$= 45,65 \sqrt{1 - 0,0420}$$

$$= 45,65 \sqrt{0,97979}$$

$$= 45,65 \times 0,98$$

$$= 44,74$$

Table 44 for $s_y$ = 44,74

| Observed Results $\bar{y}o$ | Estimated Results $\bar{y}e$ | Estimated Results − ( ) $s_y$ | Estimated Results + ( ) $s_y$ |
|---|---|---|---|
| 25,01 | 12,28 | $\bar{y}e$ − 1 $s_y$ = -32,46 | $\bar{y}e$ +1 $s_y$ = 57,02 |
| 4,19 | 12,88 | $\bar{y}e$ − 1 $s_y$ = -31,86 | $\bar{y}e$ +1 $s_y$ = 57,62 |
| 3,64 | 13,49 | $\bar{y}e$ − 1 $s_y$ = -31,25 | $\bar{y}e$ +1 $s_y$ = 58,23 |
| 15,58 | 14,00 | $\bar{y}e$ − 1 $s_y$ = -30,74 | $\bar{y}e$ +1 $s_y$ = 58,74 |
| 16,04 | 14,70 | $\bar{y}e$ − 1 $s_y$ = -30,04 | $\bar{y}e$ +1 $s_y$ = 59,44 |
| 14,90 | 15,30 | $\bar{y}e$ − 1 $s_y$ = -29,44 | $\bar{y}e$ +1 $s_y$ = 60,04 |
| 19,18 | 15,91 | $\bar{y}e$ − 1 $s_y$ = -28,83 | $\bar{y}e$ +1 $s_y$ = 60,65 |
| 16,67 | 16,51 | $\bar{y}e$ − 1 $s_y$ = -28,23 | $\bar{y}e$ +1 $s_y$ = 61,25 |

$$X^2 = \sum \frac{(fo - fe)^2}{fe}$$

| Frequencies | | | | | |
|---|---|---|---|---|---|
| Grades | $fo$ | $fe$ | $(fo-fe)$ | $(fo-fe)^2$ | $\frac{(fo-fe)^2}{fe}$ |
| $\frac{1}{4}$ | 25,01 | 12,28 | 12,73 | 162,05 | 13,20 |
| $\frac{1}{2}$ | 4,19 | 12,88 | -8,69 | 75,52 | 5,86 |
| $\frac{3}{4}$ | 3,64 | 13,49 | -9,85 | 97,02 | 7,19 |
| 1 | 15,58 | 14,00 | 1,49 | 2,22 | 0,16 |
| $1\frac{1}{4}$ | 16,04 | 14,70 | 1,34 | 1,80 | 0,12 |
| $1\frac{1}{2}$ | 14,90 | 15,30 | -0,40 | 0,16 | 0,01 |
| $1\frac{3}{4}$ | 19,18 | 15,91 | 3,27 | 10,69 | 0,67 |
| 2 | 16,67 | 16,51 | 0,16 | 0,03 | 0,00 |
| TOTAL | | | | $X^2$ | 27,21 |

$$d.f. = n - 1$$
$$= 8 - 1$$
$$= 7$$

# APPENDIX 8

## ANALYSIS OF THE AVERAGE PERCENTAGE OF MISSED SIGNALS FOR 30 SUBJECTS

$$r = \frac{[n \sum t_i y_i - (\sum t_i)(\sum y_i)]}{\sqrt{[n \sum t_i^2 - (\sum t_i)^2][(n \sum y_i^2 - (\sum y_i)^2]}}$$

$$= \frac{[8 \times 437,05 - (9)\ (387,43)]}{\sqrt{[8 \times 12,75 - (9)^2][8 \times 19071,39 - (387,43)^2]}}$$

$$= \frac{[3496,40 - 3486,87]}{\sqrt{[102,00 - 81][152571,12 - 150102,00]}}$$

$$= \frac{9,53}{\sqrt{21 \times 2469,12}}$$

$$= \frac{9,53}{\sqrt{51851,52}}$$

$$= \frac{9,53}{227,71}$$

$$= 0,0418514$$

$$by = \frac{[A]}{[B]}$$

$$= \frac{[\, n \sum t_i y_i \; - \; (\sum t_i \cdot (\sum y_i)\,]}{[\, n \sum t_i^2 \; - \; (\sum t_i)^2\,]}$$

$$= \frac{9{,}53}{21}$$

$$= 0{,}45$$

1. $ye = b_y t + (\overline{y} - tb_y)$

$= 0{,}45 \times 0{,}25 + (48{,}43 - 1{,}13 \times 0{,}45)$

$= 0{,}11 + (48{,}43 - 1{,}13 \times 0{,}45)$

$= 0{,}11 + (48{,}43 - 0{,}51)$

$= 0{,}11 + 47{,}92$

$= 48{,}03$

2. $ye = b_y t + (\overline{y} - \overline{t} b_y)$

$= 0{,}45 \times 0{,}50 + 47{,}92$

$= 0{,}23 + 47{,}92$

$= 48{,}15$

3. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 0,45 \times 0,75 + 47,92$

$= 0,34 + 47,92$

$= 48,26$

4. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 0,45 \times 1 + 47,92$

$= 0,45 + 47,92$

$= 48,37$

5. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 0,45 \times 1,25 + 47,92$

$= 0,56 + 47,92$

$= 48,48$

6. $ye = b_y t + (\bar{y} - t b_y)$

$= 0,45 \times 1,50 + 47,92$

$= 0,68 + 47,92$

$= 48,60$

7. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 0,45 \times 1,75 + 47,92$

$= 0,79 + 47,92$

$= 48,71$

8. $ye = b_y t + (\bar{y} - \bar{t} b_y)$

$= 0,45 \times 2 + 47,92$

$= 0,90 + 47,92$

$= 48,82$

Standard error in the estimate of :

$$Sy = s_y \sqrt{1 - r^2}$$

where

$$s_y = \frac{y^2}{n} - \bar{y}^2$$

$$= \frac{19071,39}{8} - 2345,46$$

$$= 2383,92 - 2345,46$$

$$= 38,46$$

$$Sy = s_y \sqrt{1 - r^2}$$

$$= 38,46 \sqrt{1 - (0,0418514)^2}$$

$$= 38,46 \sqrt{1 - 0,00174}$$

$$= 38,46 \sqrt{0,99826}$$

$$= 38,46 \times 0,32$$

$$= 12,31$$

Table 45 for $S_y$ = 12,31

| Observed Results $\overline{y}o$ | Estimated Results $\overline{y}e$ | Estimated Results - ( ) $S_y$ | Estimated Results + ( ) $S_y$ |
|---|---|---|---|
| 55,70 | 48,03 | $\overline{y}e - 1 S_y$ =35,72 | $\overline{y}e + 1 S_y$ = 60,34 |
| 46,44 | 48,15 | $\overline{y}e - 1 S_y$ =35,84 | $\overline{y}e + 1 S_y$ = 60,46 |
| 51,05 | 48,26 | $\overline{y}e - 1 S_y$ =35,95 | $\overline{y}e + 1 S_y$ = 60,57 |
| 41,31 | 48,37 | $\overline{y}e - 1 S_y$ =36,06 | $\overline{y}e + 1 S_y$ = 60,68 |
| 40,43 | 48,48 | $\overline{y}e - 1 S_y$ =36,17 | $\overline{y}e + 1 S_y$ = 60,79 |
| 47,86 | 48,60 | $\overline{y}e - 1 S_y$ =36,29 | $\overline{y}e + 1 S_y$ = 60,91 |
| 45,26 | 48,71 | $\overline{y}e - 1 S_y$ =36,40 | $\overline{y}e + 1 S_y$ = 61,02 |
| 59,38 | 48,82 | $\overline{y}e - 1 S_y$ =36,51 | $\overline{y}e + 1 S_y$ = 61,13 |

$$\chi^2 = \sum \frac{(fo - fe)^2}{fe}$$

| Frequencies | | | | | |
|---|---|---|---|---|---|
| Grades | $fo$ | $fe$ | $(fo-fe)$ | $(fo-fe)^2$ | $\frac{(fo-fe)^2}{fe}$ |
| $\frac{1}{4}$ | 55,70 | 48,03 | 7,69 | 59,14 | 1,23 |
| $\frac{1}{2}$ | 46,44 | 48,15 | -1,71 | 2,92 | 0,06 |
| $\frac{3}{4}$ | 51,05 | 48,26 | 2,79 | 7,78 | 1,16 |
| 1 | 41,31 | 48,37 | -7,06 | 49,84 | 1,03 |
| $1\frac{1}{4}$ | 40,43 | 48,48 | -8,05 | 64,80 | 1,34 |
| $1\frac{1}{2}$ | 47,86 | 48,60 | -0,74 | 0,55 | 0,01 |
| $1\frac{3}{4}$ | 45,26 | 48,71 | -3,45 | 11,90 | 0,24 |
| 2 | 59,38 | 48,82 | 10,56 | 111,51 | 2,28 |
| TOTAL | | | | $\chi^2$ | 6,35 |

$$d.f. = n - 1$$
$$= 8 - 1$$
$$= 7$$

# APPENDIX 9

# ORDER AND DIAGRAMS OF GEOMETRIC FIGURES

Table 46 Order of Slide Presentation

| Slide Number | Slide | Slide Number | Slide |
|---|---|---|---|
| Practice 1 | P1, P, P1 | Test 23 | C1a, C, C1a |
| " 2 | P1a, P, P1a | " 24 | E1a, E, E1a |
| | | " 25 | F1f, F, F1f |
| Test 1 | F1c, F, F1c | " 26 | D2c, D, D2c |
| Test 2 | D2a, D, D2a | " 27 | A2, A, A2 |
| Test 3 | A4, A, A4 | " 28 | G2b, G, G2B |
| Test 4 | G1a, G, G1a | " 29 | B1, B, B1 |
| Test 5 | B2, B, B2 | " 30 | H1, H, H1 |
| Test 6 | H1a, H, H1a | " 31 | C3a, C, C3a |
| Test 7 | C4a, C, C4a | " 32 | E4a, E, E4a |
| Test 8 | E3a, E, E3a | " 33 | F1, F, F1 |
| Test 9 | F1d, F, F1d | " 34 | D1a, D, D1a |
| Test 10 | D2, D, D2 | " 35 | A3, A, A3 |
| Test 11 | A1a, A, A1a | " 36 | G2a, G, G2a |
| Test 12 | G3, G, G3 | " 37 | B2c, B, B2c |
| Test 13 | B1c, B, B1c, | " 38 | H2a, H, H2a |
| Test 14 | H1b, H, H1b | " 39 | C2, C, C2 |
| Test 15 | C5, C, C5 | " 40 | E5, E, E5 |
| Test 16 | E2a, E, EZa | " 41 | F1a, F, F1a |
| Test 17 | F1i, F, F1i | " 42 | D2b, D, D2b |
| Test 18 | D1b, D, D1b | " 43 | A5a, A, A5a |
| Test 19 | A5, A, A5 | " 44 | G1c, G, G1c |
| Test 2o | G1b, G, G1b | " 45 | B2a, B, B2a |
| Test 21 | B1d, B, B1d | " 46 | H5a, H, H5a |
| Test 22 | H4a, H, H4a | " 47 | C4, C, C4 |

Cont...

Table 46 Order of slide presentation

| Slide Number | Slide | Slide Number | Slide |
|---|---|---|---|
| Test 48 | E5a, E, E5a | Test 65 | F1b, F, F1b |
| " 49 | F1h, F, F1h | " 66 | D2d, D, D2d |
| " 50 | D1c, D, D1c | " 67 | A2a, A, A2a |
| " 51 | A4a, A, A4a | " 68 | G1, G, G1 |
| " 52 | G2, G, G2 | " 69 | B1b, B, B1b |
| " 53 | B2b, B, B2b | " 70 | H1c, H, H1c |
| " 54 | H1d, H, H1d | " 71 | C2a, C, C2a |
| " 55 | C3, C, C3 | " 72 | E4, E, E4 |
| " 56 | E2, E, E2 | " 73 | F1e, F, F1e |
| " 57 | F1g, F, F1g | " 74 | D1, D, D1 |
| " 58 | D1d, D, D1d | " 75 | A3a, A, A3a |
| " 59 | A1, A, A1 | " 76 | G3b, G, G3b |
| " 60 | G3a, G, G3a | " 77 | B1a, B, B1a |
| " 61 | B2d, B, B2d | " 78 | H6a, H, H6a |
| " 62 | H3a, H, H3a | " 79 | C5a, C, C5a |
| " 63 | C1, C, C1 | " 80 | E3, E, E3 |
| " 64 | E1, E, E1 | | |

Table 47 Order of Slide Presentation

| Slide Number | | Slide | Slide Number | | Slide |
|---|---|---|---|---|---|
| Practice | 1 | P, P1 | Test | 24 | F,F1a |
| " | 2 | P, P1a | " | 25 | A, A1 |
| Test | 1 | D, D2b | " | 26 | F,F2c |
| " | 2 | B, B2 | " | 27 | D,D6a |
| " | 3 | A, A1c | " | 28 | D,D10a |
| " | 4 | E, E1c | " | 29 | C,C3b |
| " | 5 | H, H1a | " | 30 | E,E4a |
| " | 6 | C, C4a | " | 31 | F,F1h |
| " | 7 | E, E5b | " | 32 | E,E3a |
| " | 8 | B, B7a | " | 33 | G,G2d |
| " | 9 | E, E4b | " | 34 | C,C4b |
| " | 10 | D, D1a | " | 35 | G,G2c |
| " | 11 | D, D8a | " | 36 | G,G3d |
| " | 12 | H, H3a | " | 37 | F,F3a |
| " | 13 | C, C2b | " | 38 | C,C1a |
| " | 14 | F, F1d | " | 39 | B,B8a |
| " | 15 | C, C4 | " | 40 | H,H1f |
| " | 16 | G, G2b | " | 41 | C,C4c |
| " | 17 | B, B6a | " | 42 | D,D4b |
| " | 18 | A, A3 | " | 43 | H,H1 |
| " | 19 | H, H1c | " | 44 | B,B1d |
| " | 20 | G, G3c | " | 45 | C,C5 |
| " | 21 | A, A2a | " | 46 | F,F7a |
| " | 22 | F, F3b | " | 47 | E,E1 |
| " | 23 | H, H2a | " | 48 | H,H5a |

Cont...

Table 47 Order of Slide Presentation

| Slide Number | Slide | Slide Number | Slide |
|---|---|---|---|
| Test 49 | E, E1a | Test 74 | B, B1 |
| Test 50 | G, G6a | Test 75 | G, G1a |
| Test 51 | A, A1a | Test 76 | D, D7a |
| Test 52 | D, D2c | Test 77 | A, A2d |
| Test 53 | F, F4a | Test 78 | A, A3b |
| Test 54 | A, A4c | Test 79 | E, E2 |
| Test 55 | B, B3c | Test 80 | C, C1c |
| Test 56 | A, A2b | Test 81 | B, B2b |
| Test 57 | D, D4a | Test 82 | D, D1d |
| Test 58 | F, F5b | Test 83 | B, B2a |
| Test 59 | B, B9a | Test 84 | A, A2 |
| Test 60 | G, G1b | Test 85 | E, E3c |
| Test 61 | C, C2c | Test 86 | H, H1d |
| Test 62 | F, F1e | Test 87 | C, C3 |
| Test 63 | H, H3b | Test 88 | E, E5a |
| Test 64 | H, H4a | Test 89 | B, B2d |
| Test 65 | B, B7c | Test 90 | E, E4 |
| Test 66 | A, A1b | Test 91 | D, D4c |
| Test 67 | G, G2a | Test 92 | D, D1c |
| Test 68 | D, D3a | Test 93 | F, F8a |
| Test 69 | B, B2c | Test 94 | C, C5c |
| Test 70 | E, E4c | Test 95 | F, F5a |
| Test 71 | G, G1d | Test 96 | C, C1b |
| Test 72 | E, E3 | Test 97 | G, G1 |
| Test 73 | H, H9a | Test 98 | B, B1b |



Cont...

Table 47 Order of Slide Presentation

| Slide Number | | Slide | Slide Number | | Slide |
|---|---|---|---|---|---|
| Test | 99 | A, A2c | Test | 124 | H, H1c |
| " | 100 | H, H3c | " | 125 | B, B5a |
| " | 101 | G, G3b | " | 126 | C, C1 |
| " | 102 | A, A4b | " | 127 | F, F1g |
| " | 103 | F, F4b | " | 128 | E, E2b |
| " | 104 | H, H1b | " | 129 | H, H6a |
| " | 105 | F, F2a | " | 130 | E, E1b |
| " | 106 | A, A4 | " | 131 | G, G1e |
| " | 107 | F, F1 | " | 132 | A, A5b |
| " | 108 | D, D2d | " | 133 | D, D9a |
| " | 109 | D, D1b | " | 134 | F, F1f |
| " | 110 | C, C2 | " | 135 | A, A4a |
| " | 111 | E, E5c | " | 136 | B, B4a |
| " | 112 | F, F1c | " | 137 | A, A5c |
| " | 113 | E, E3b | " | 138 | D, D1 |
| " | 114 | G, G5a | " | 139 | F, F6a |
| " | 115 | C, C2a | " | 140 | B, B3b |
| " | 116 | G, G3a | " | 141 | G, G3 |
| " | 117 | G, G7a | " | 142 | C, C3a |
| " | 118 | F, F2b | " | 143 | F, F1b |
| " | 119 | C, C5b | " | 144 | H, H5b |
| " | 120 | B, B1a | " | 145 | H, H7a |
| " | 121 | H, H1g | " | 146 | B, B5b |
| " | 122 | D, D3c | " | 147 | A, A5 |
| " | 123 | D, D2 | " | 148 | G, G2 |

Cont...

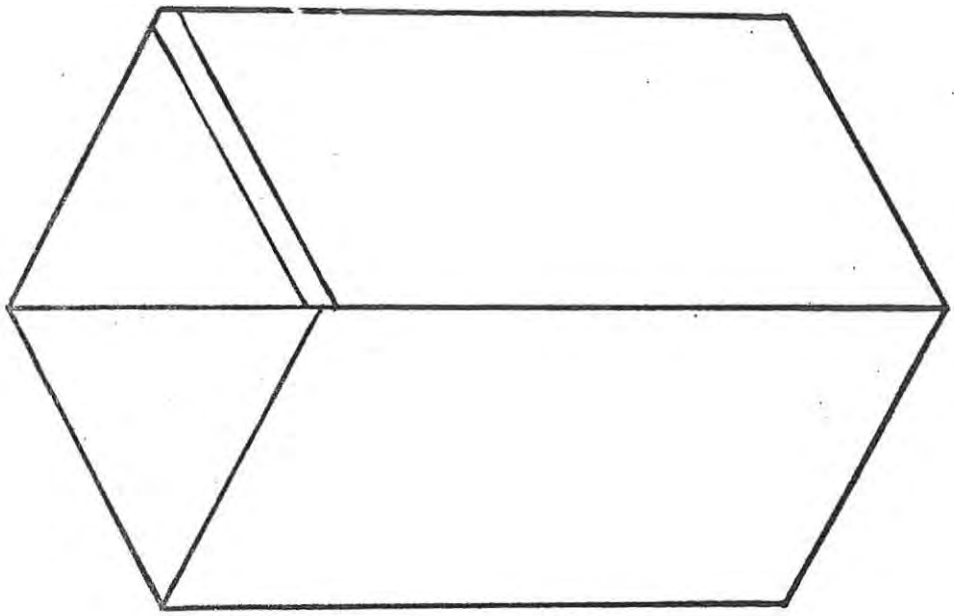
Table 47 Order of Slide Presentation

| Slide Number | Slide | Slide Number | Slide |
|---|---|---|---|
| Test 149 | D,D5a | Test 156 | G,G1c |
| " 150 | B,B3a | " 157 | D,D2a |
| " 151 | E,E5 | " 158 | A,A5a |
| " 152 | G,G4a | " 159 | A,A3a |
| " 153 | E,E2a | " 160 | E,E6a |
| " 154 | H,H10a | " 161 | C,C5a |
| " 155 | B,B1c | " 162 | B,B7b |

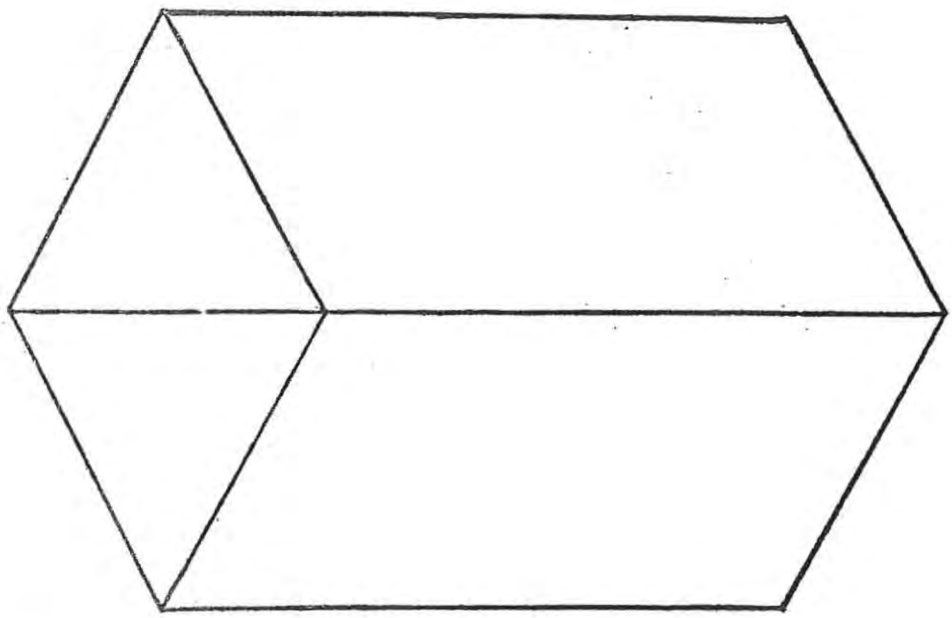
FIG. 18 pp 295 - 362

DIAGRAMS OF GEOMETRIC FIGURES

EMPLOYED



P1a



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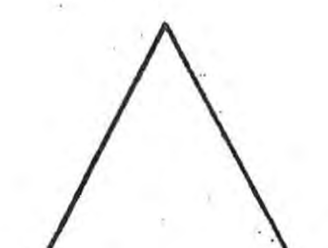

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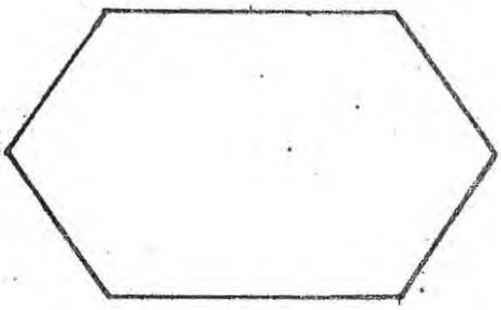

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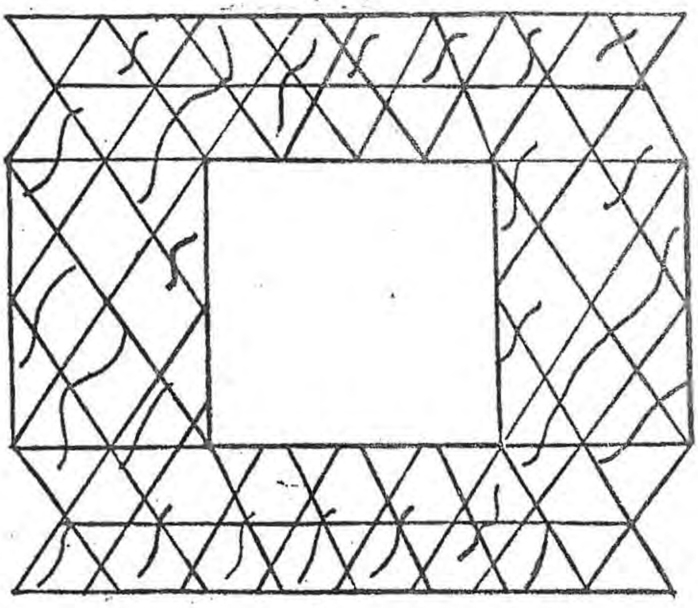

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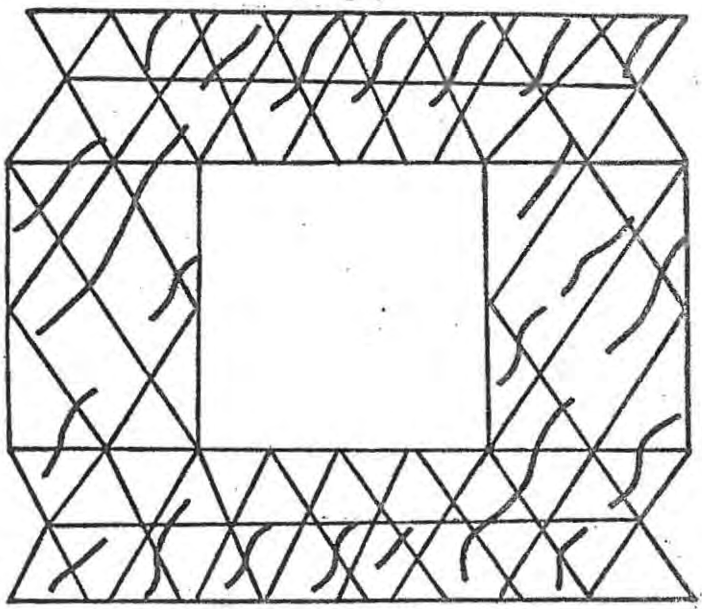

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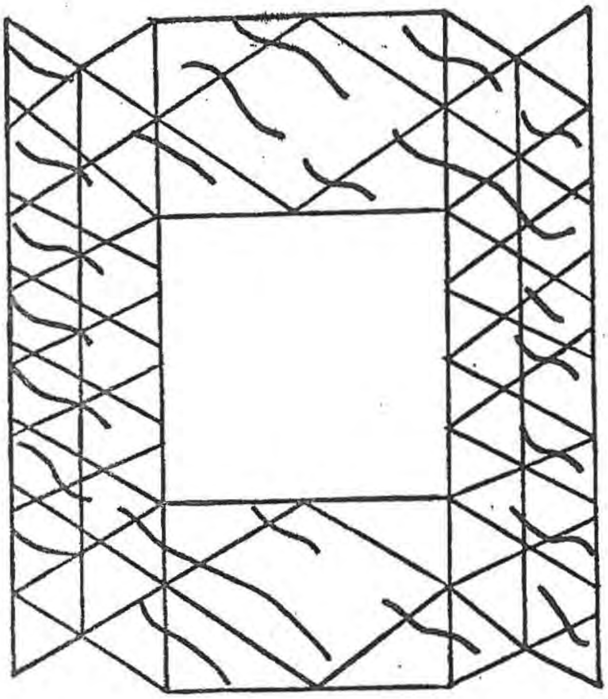
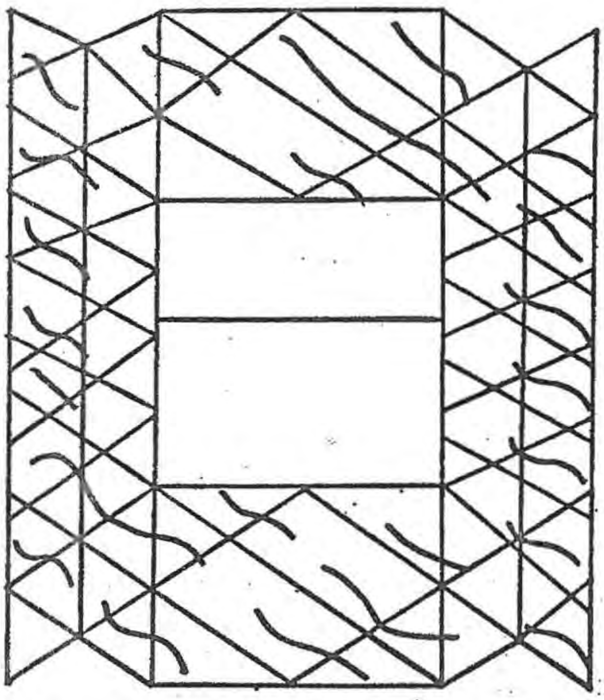


A1c



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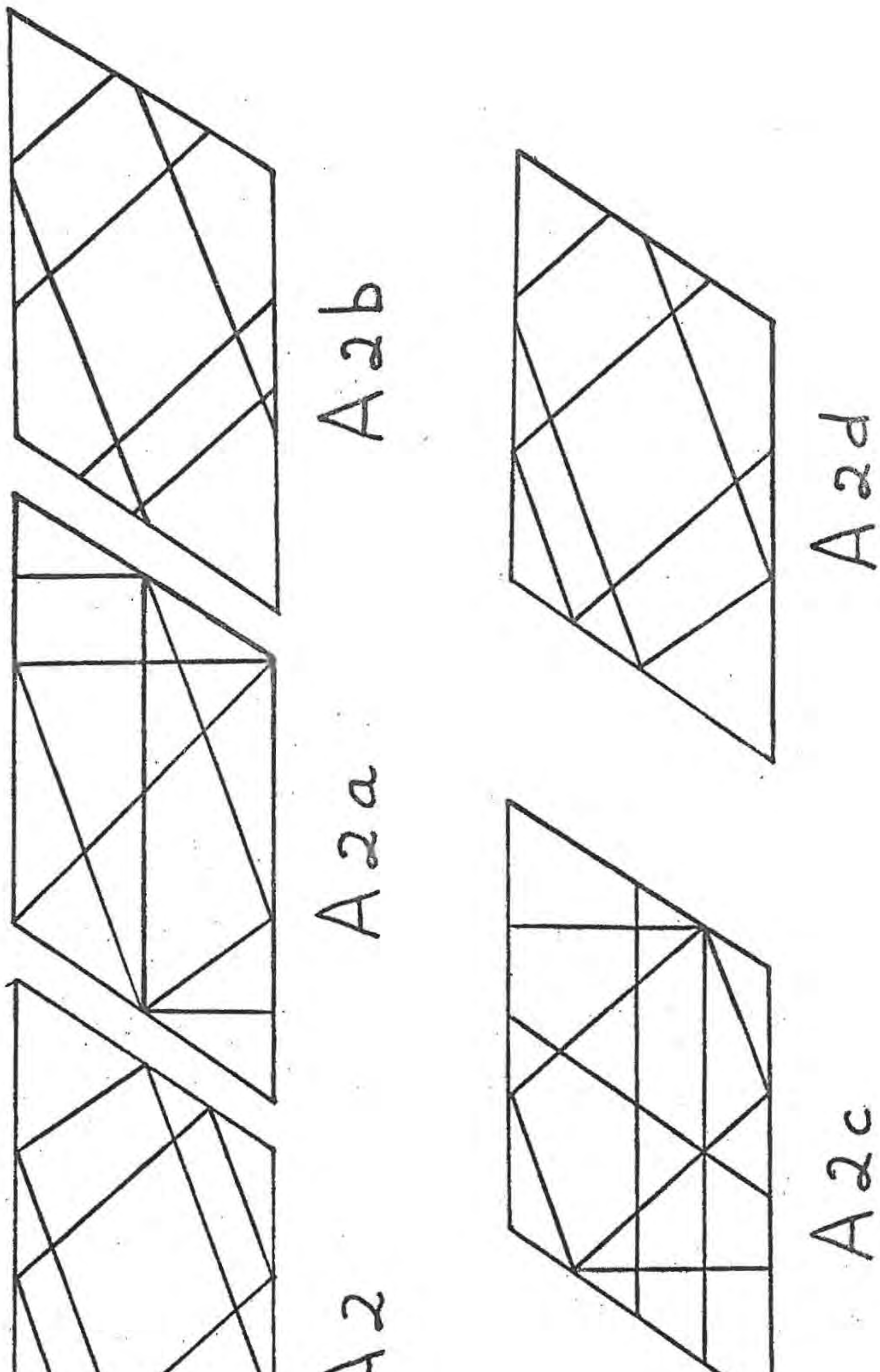
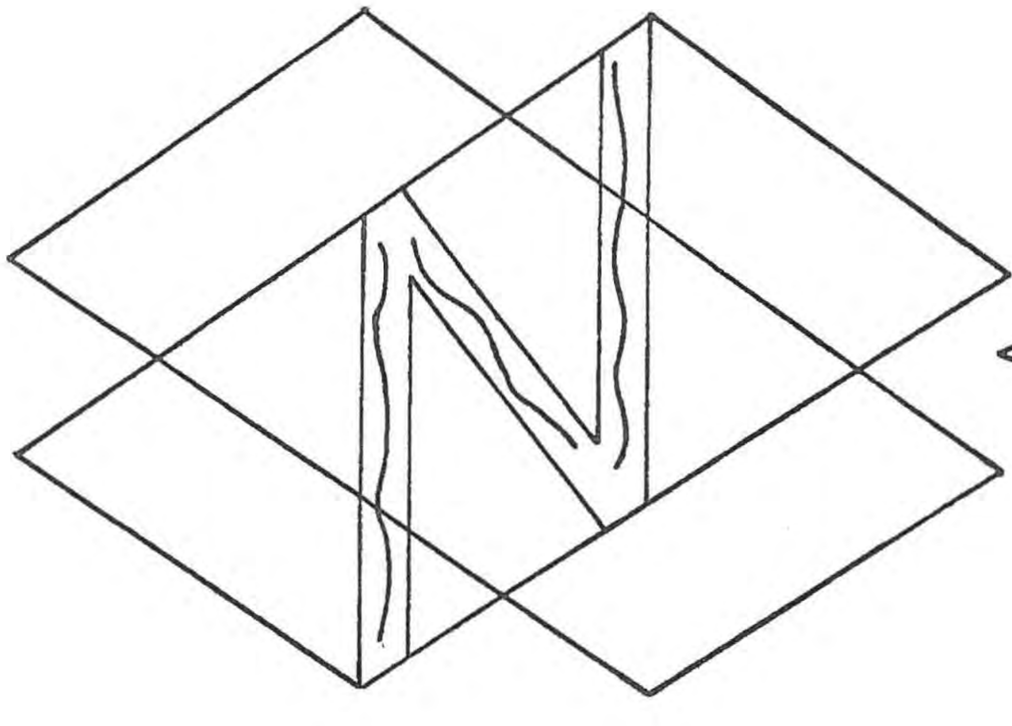

A2
A2a
A2b
A2c
A2d



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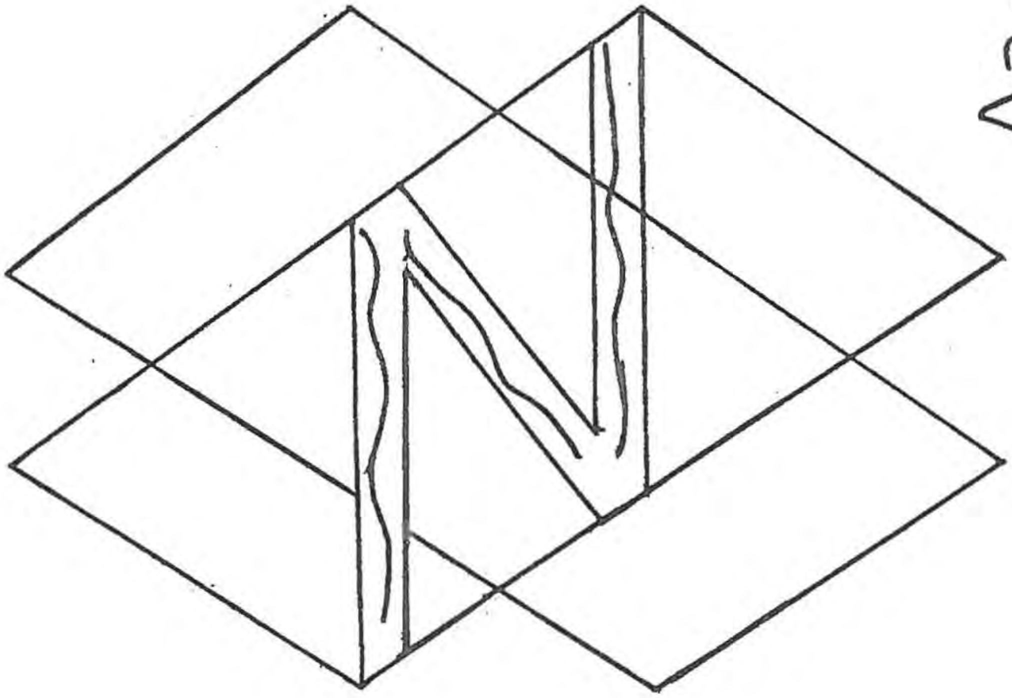

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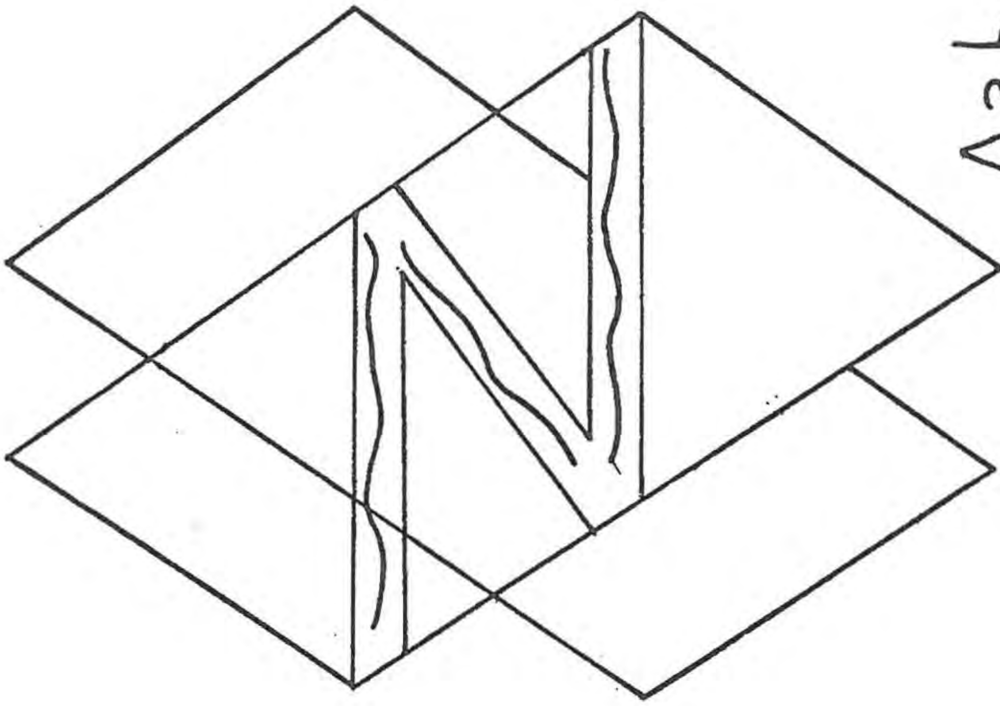

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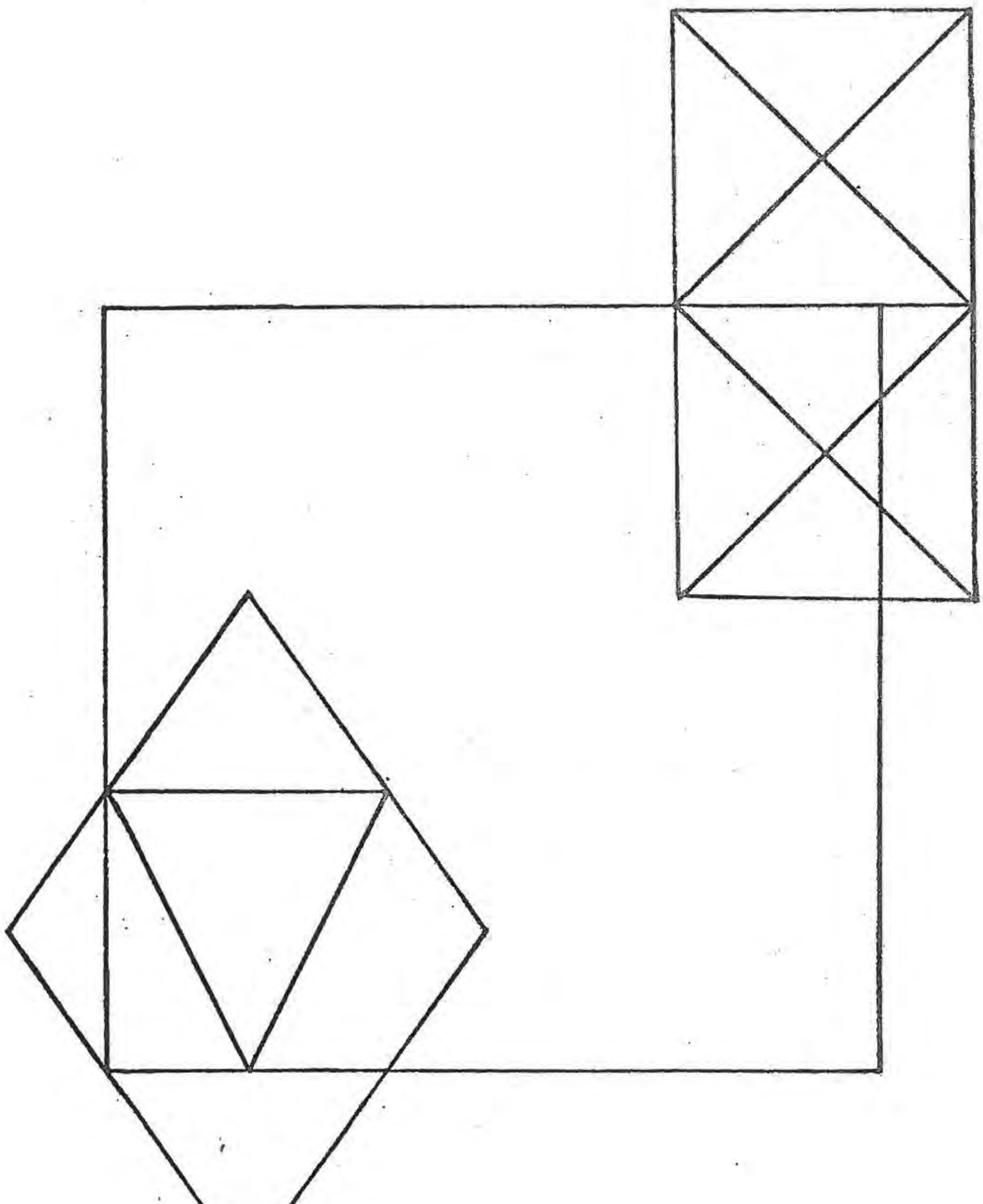

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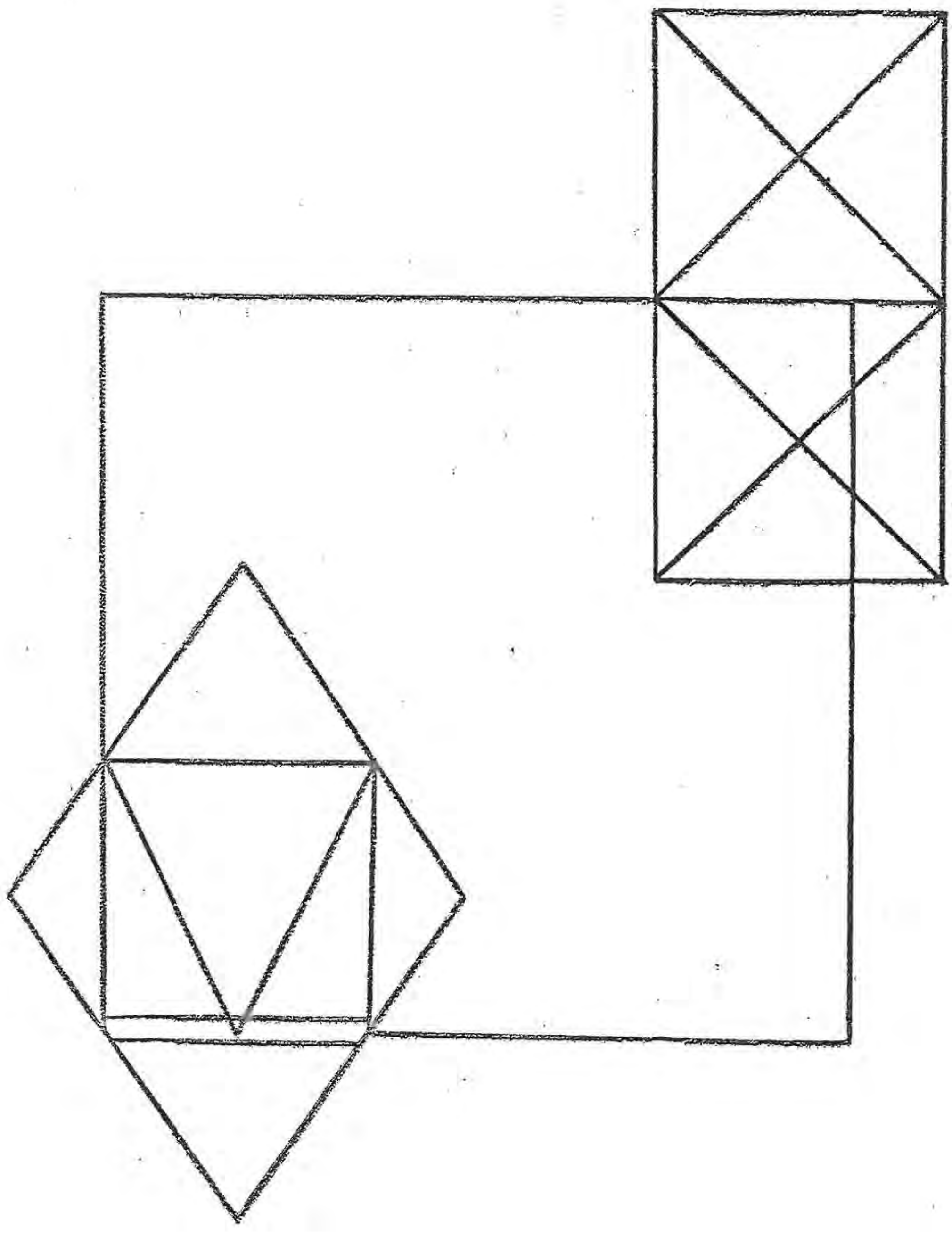

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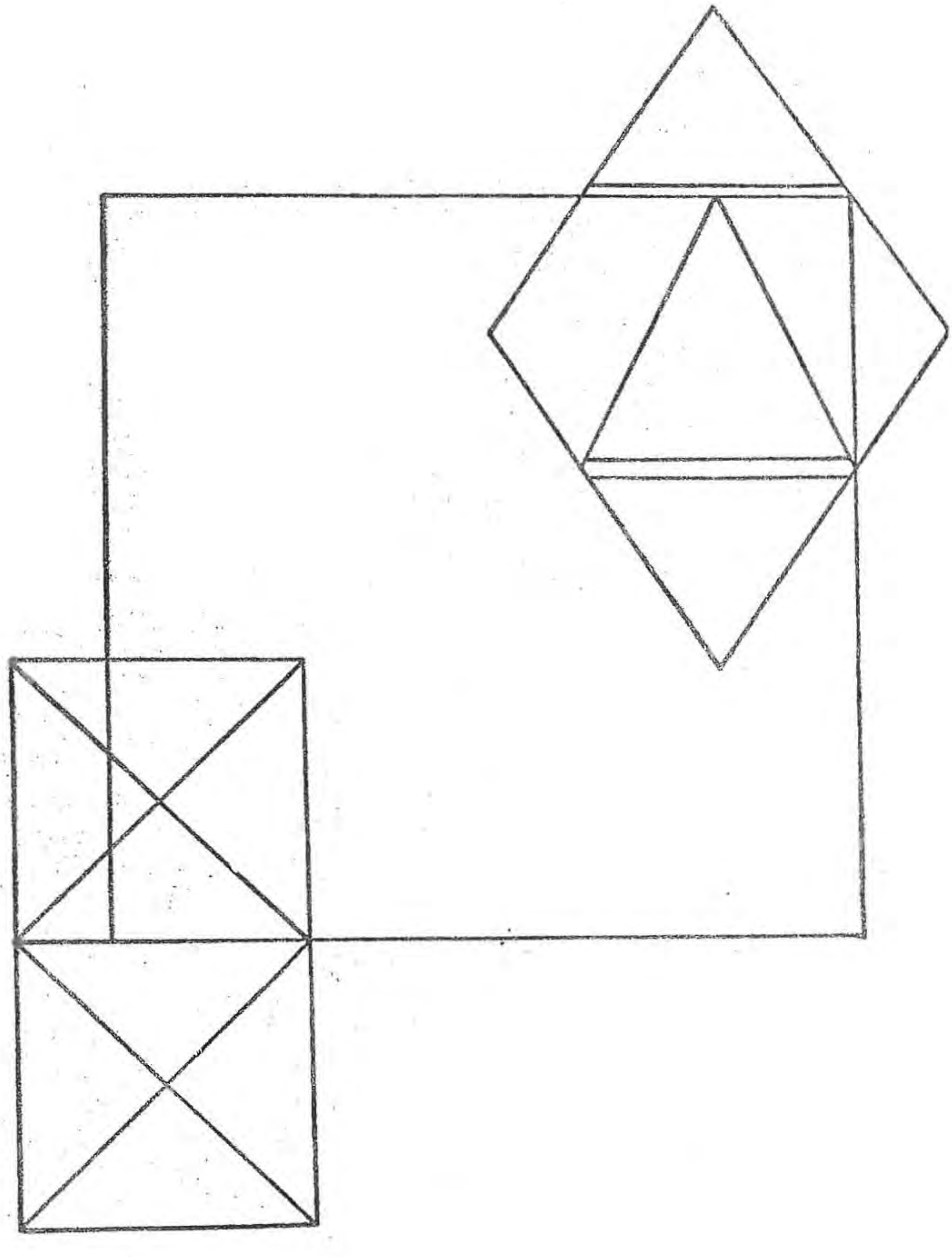
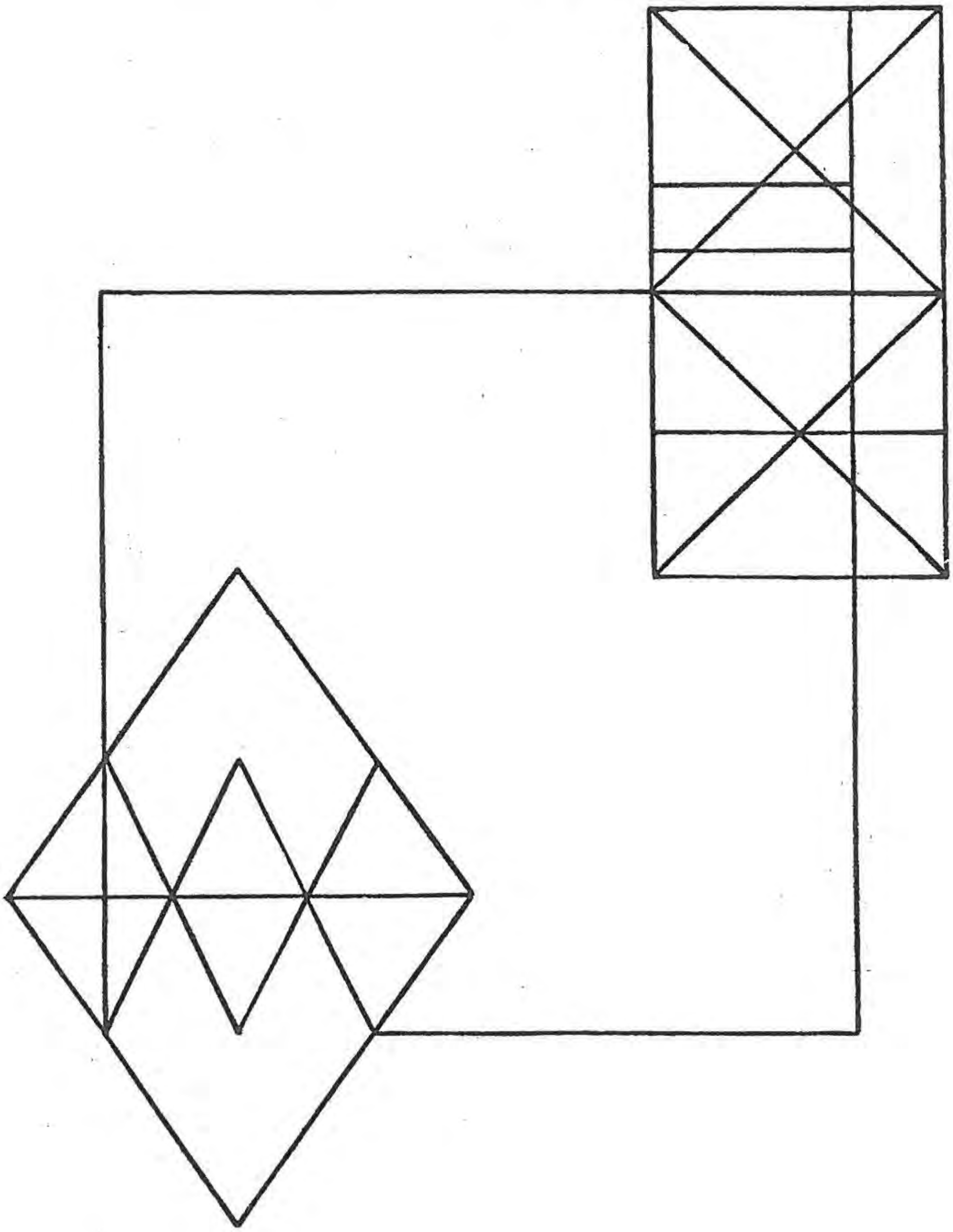
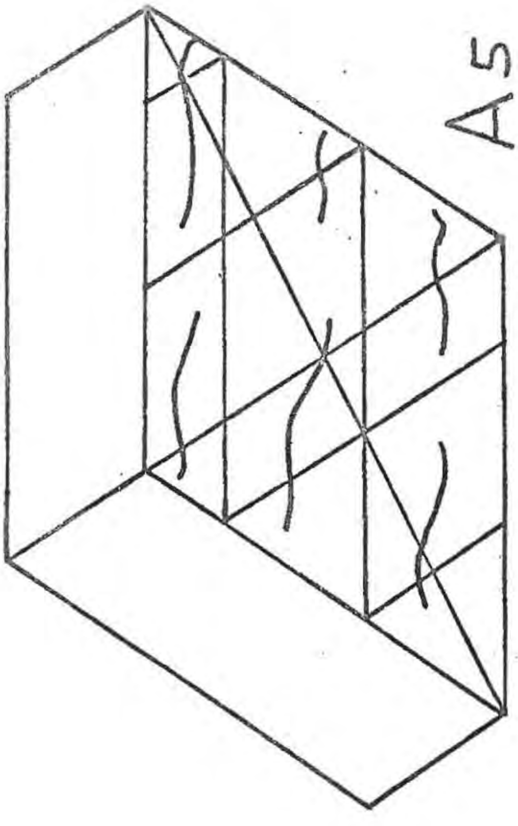


A 4 b



A 4c



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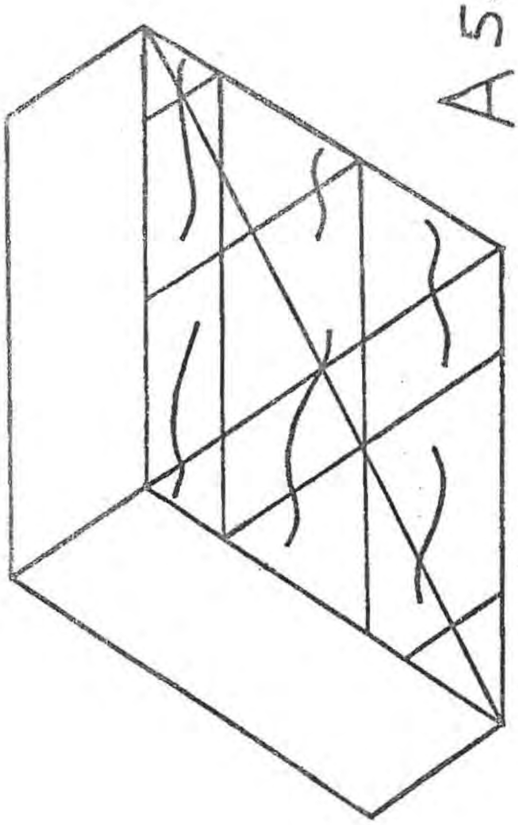

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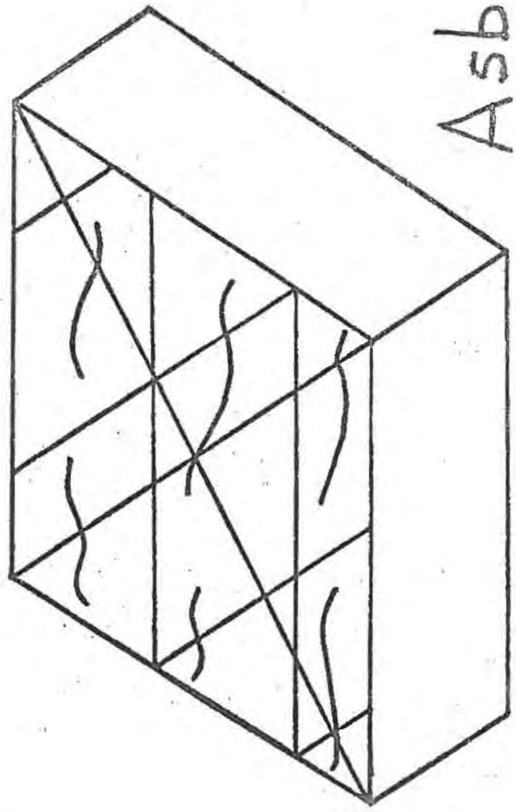

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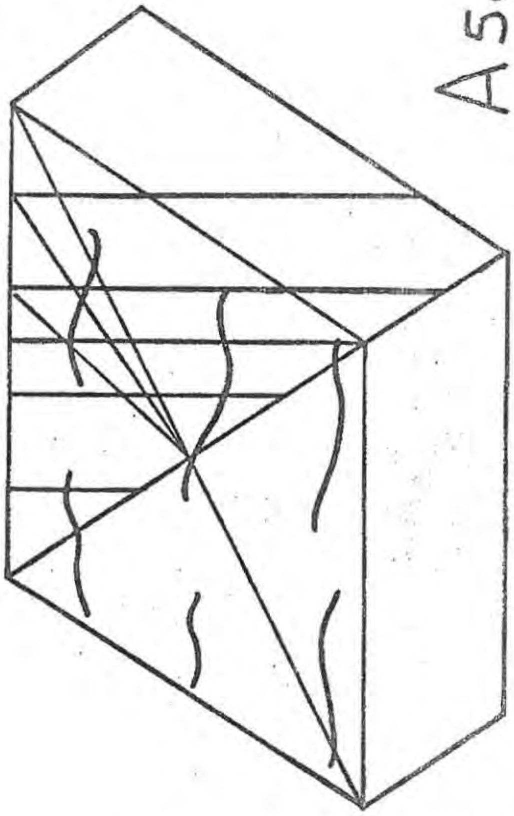

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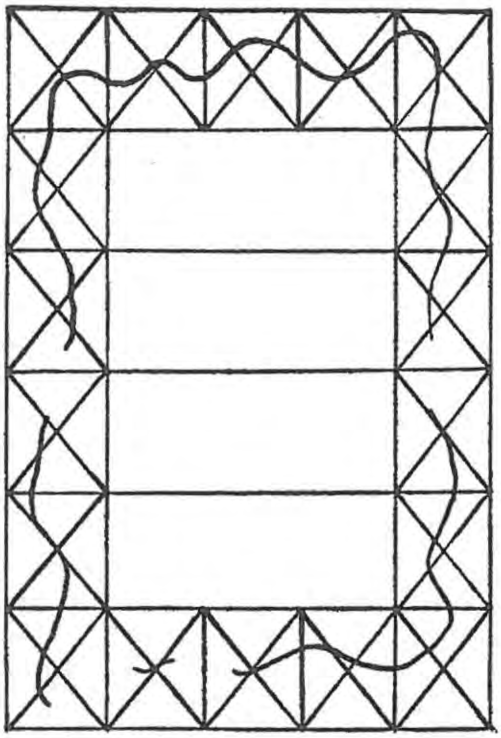

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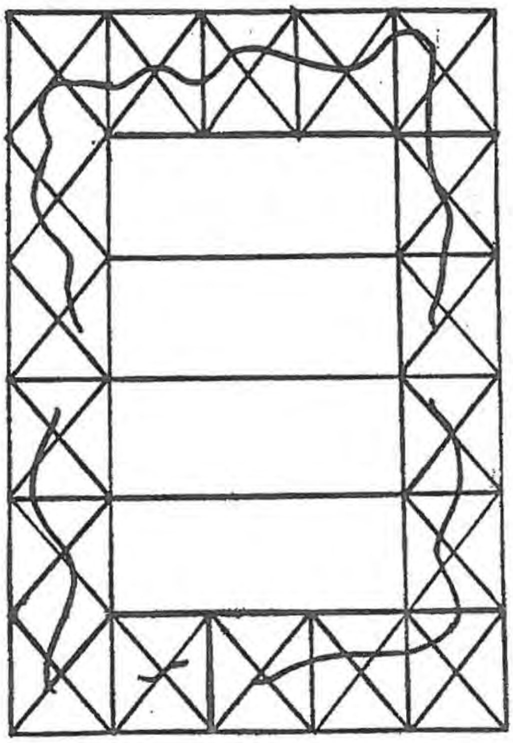
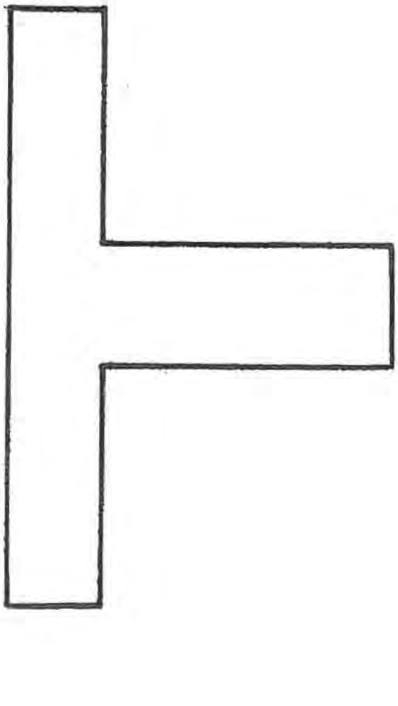
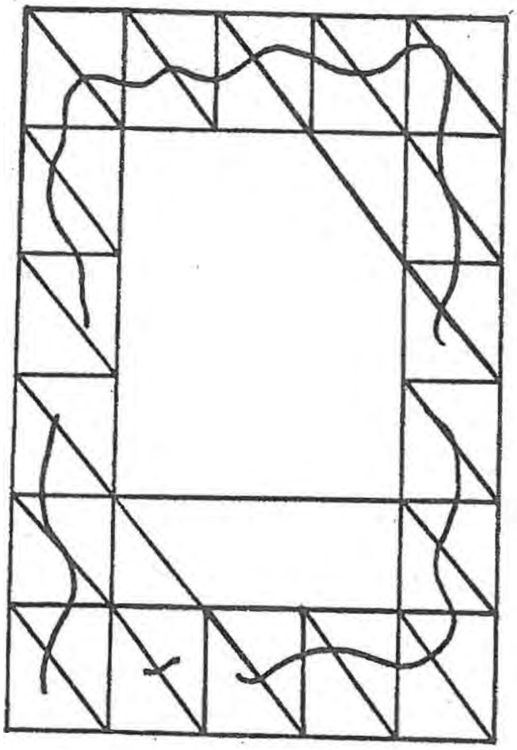


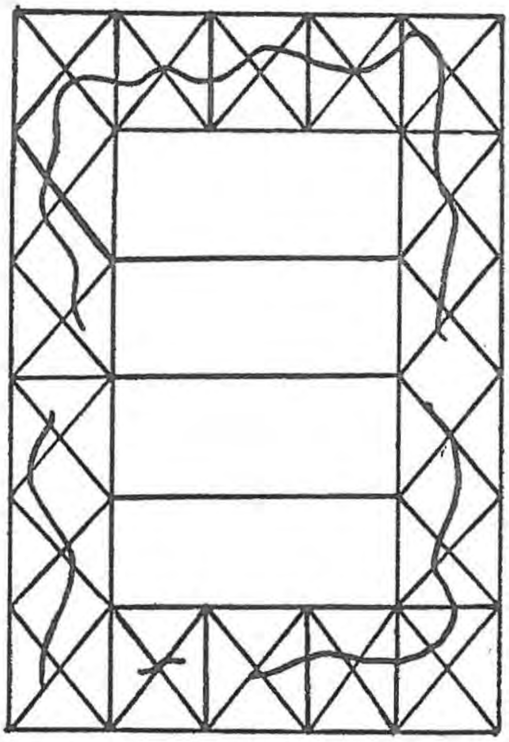
B1a



B



B1d



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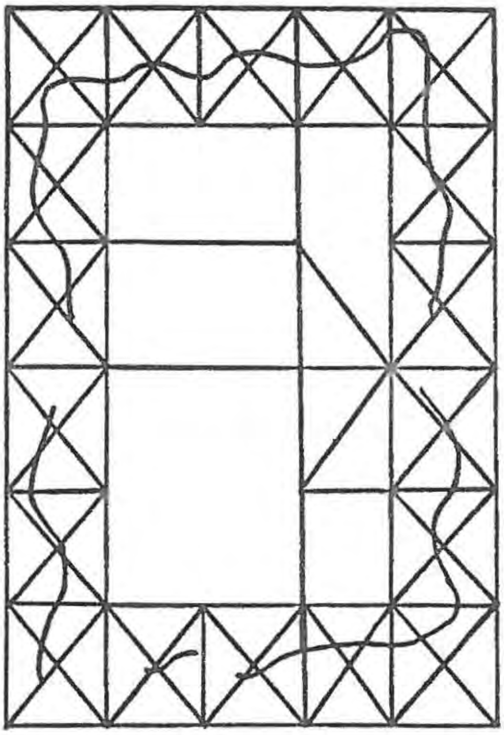

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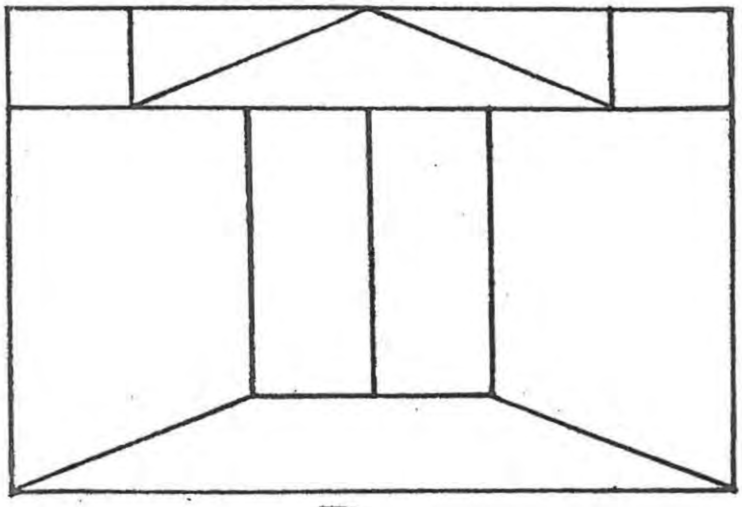

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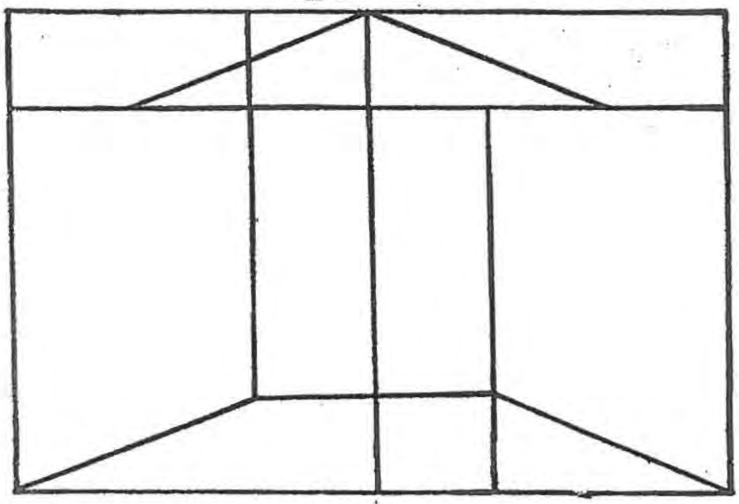

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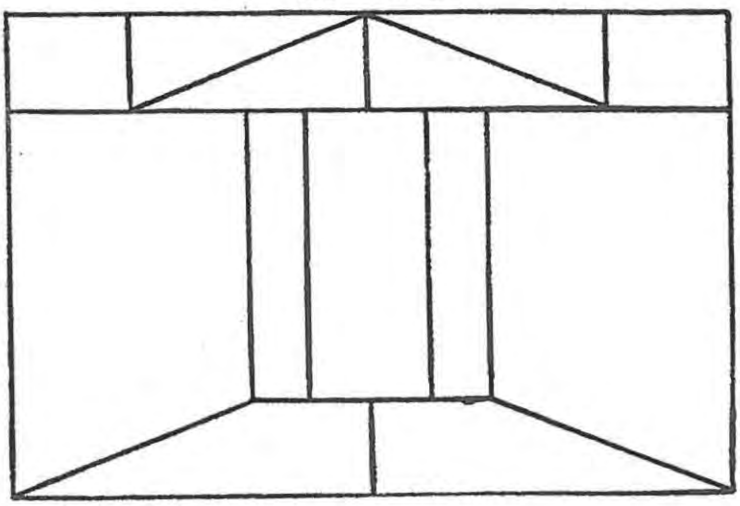

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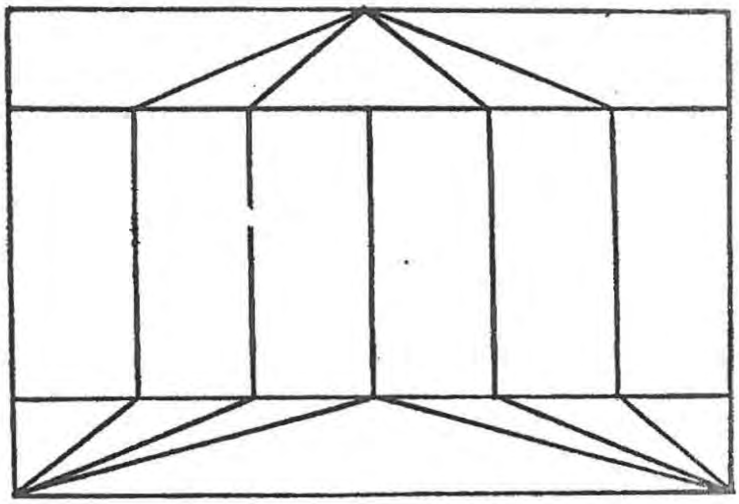

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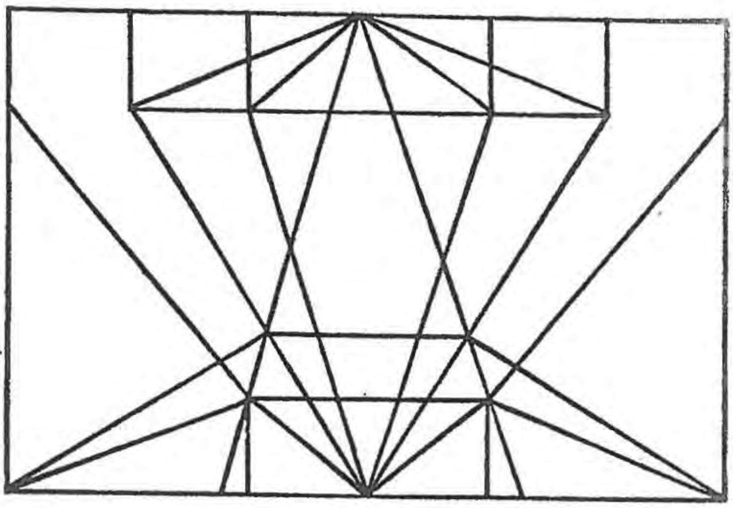

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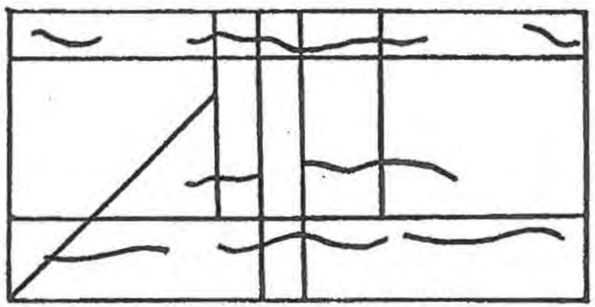

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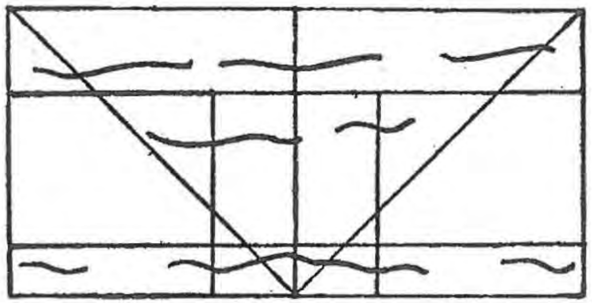

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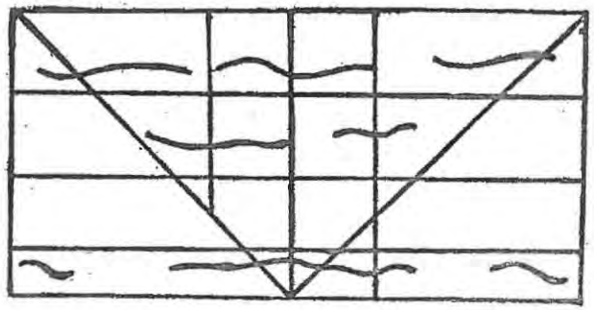

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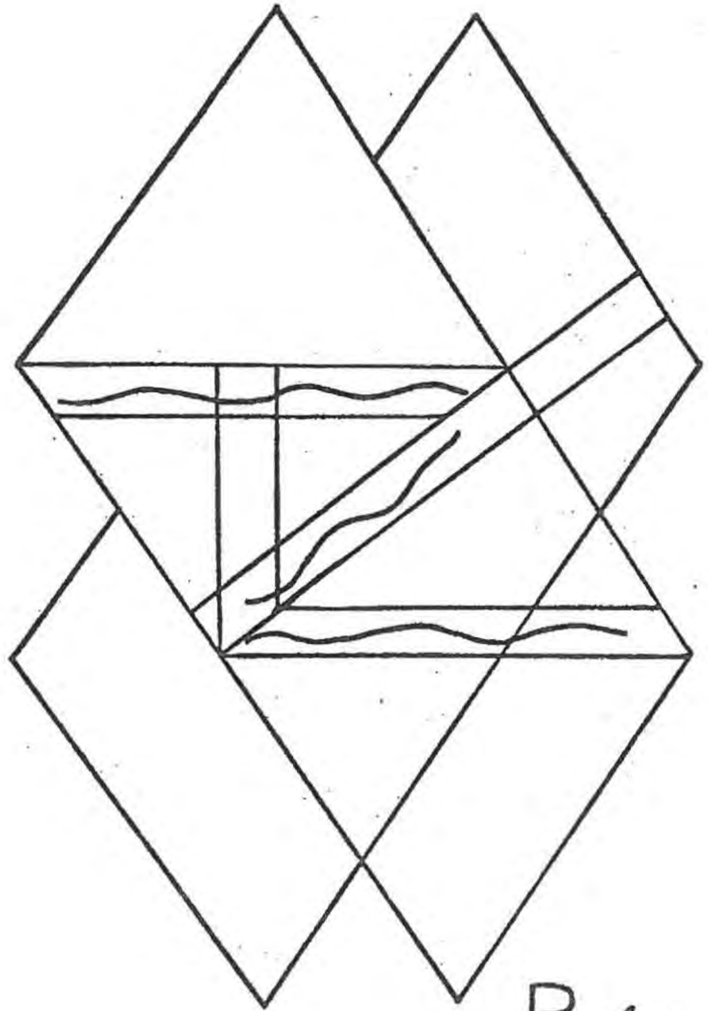

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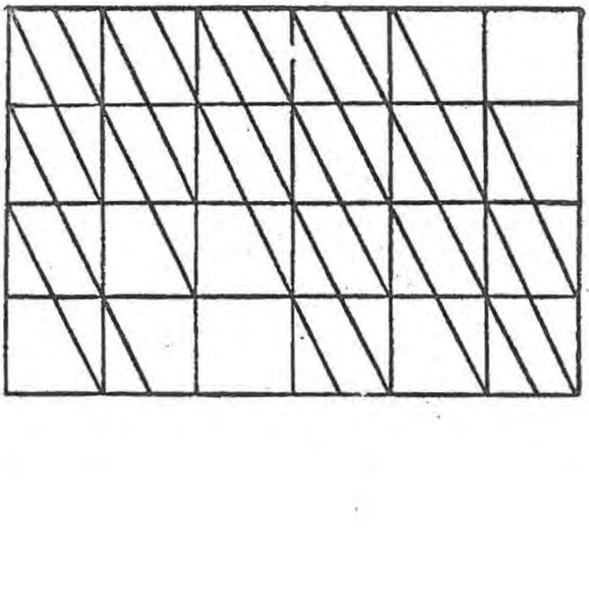

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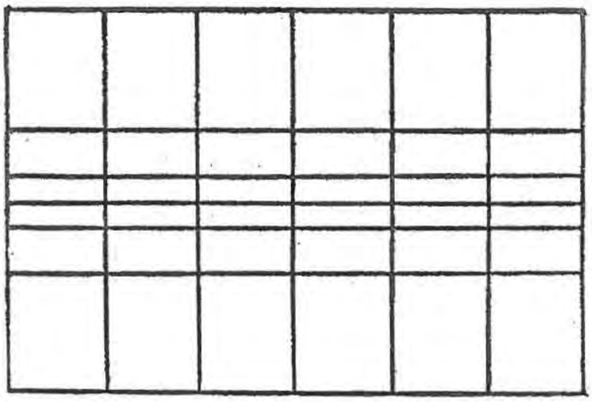

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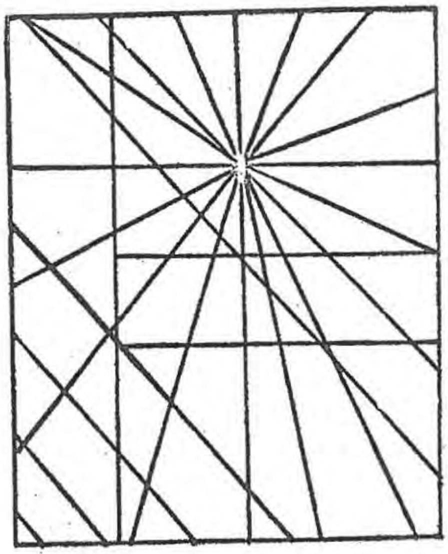

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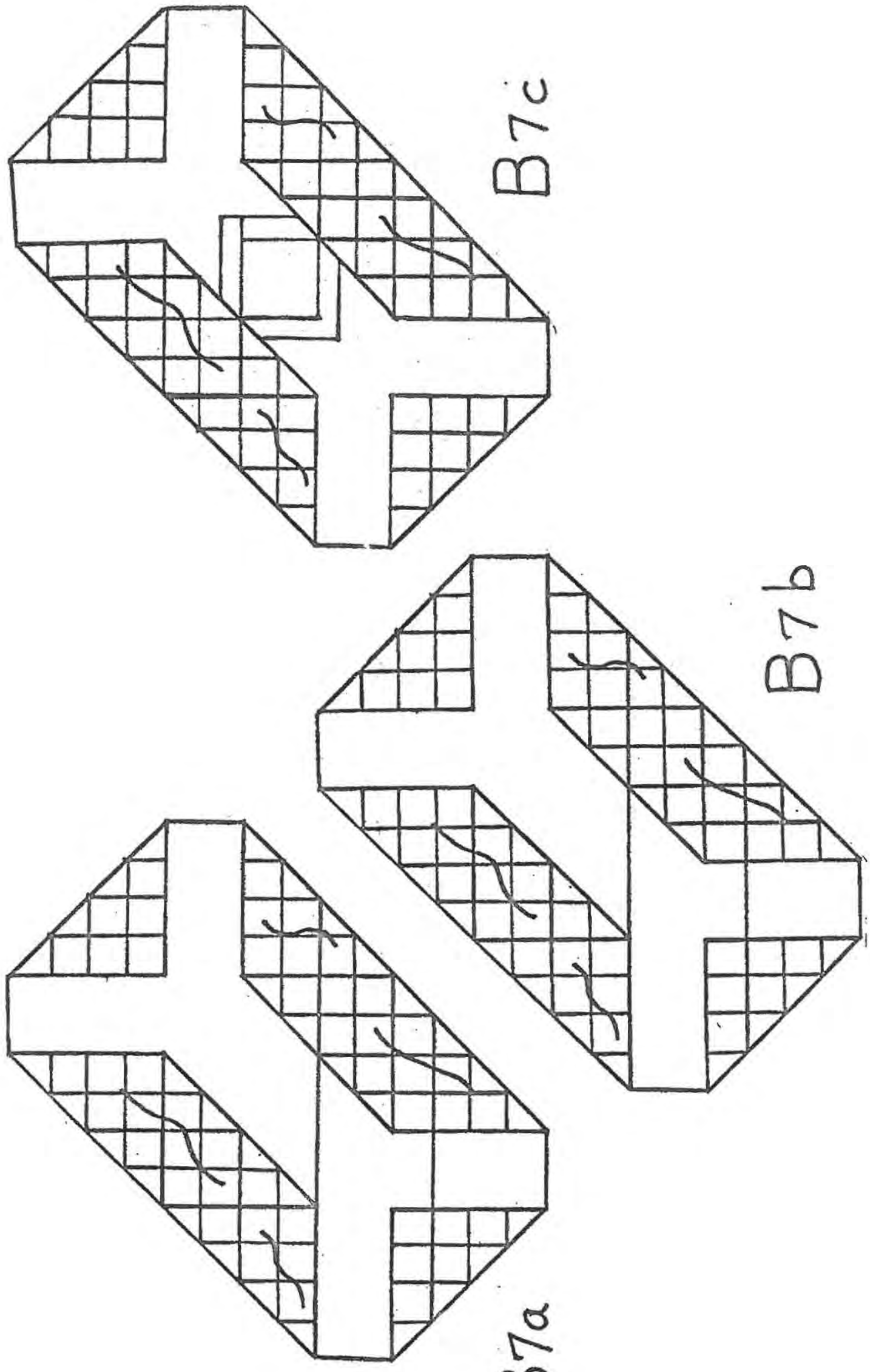
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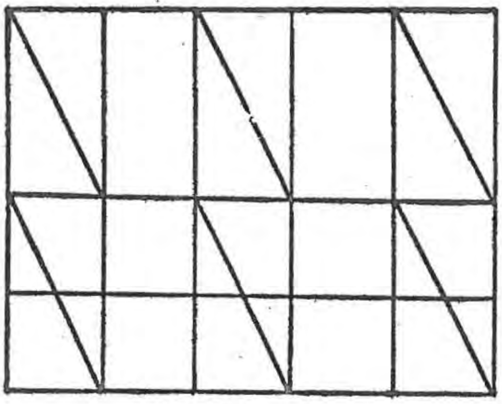

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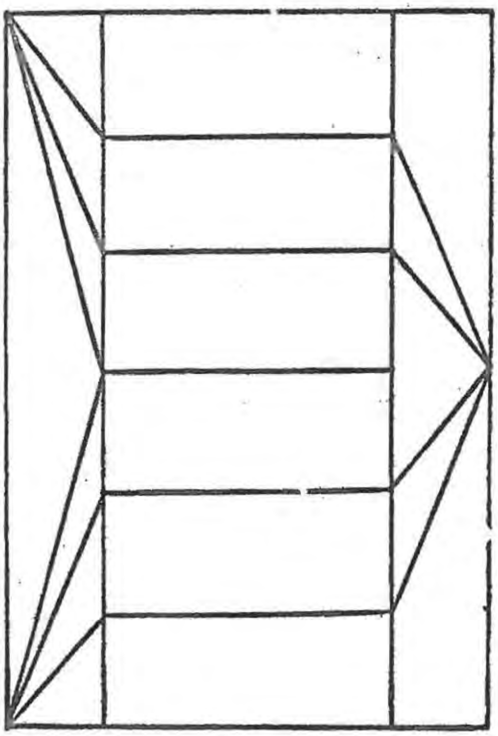

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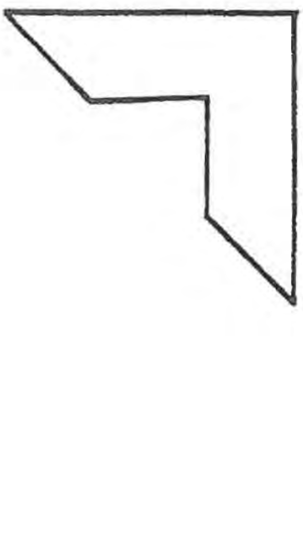

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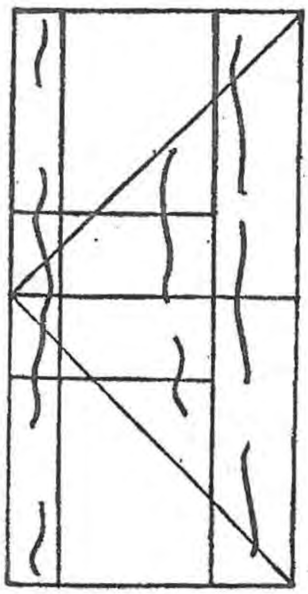

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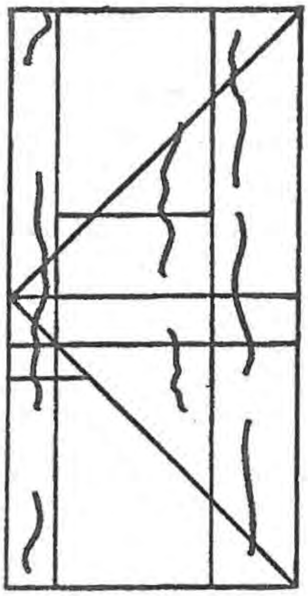

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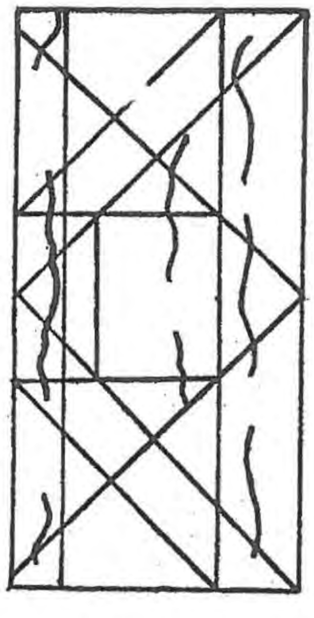

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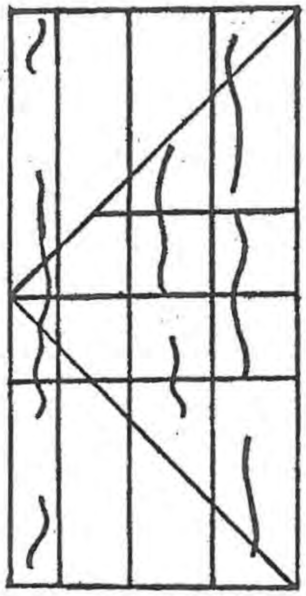

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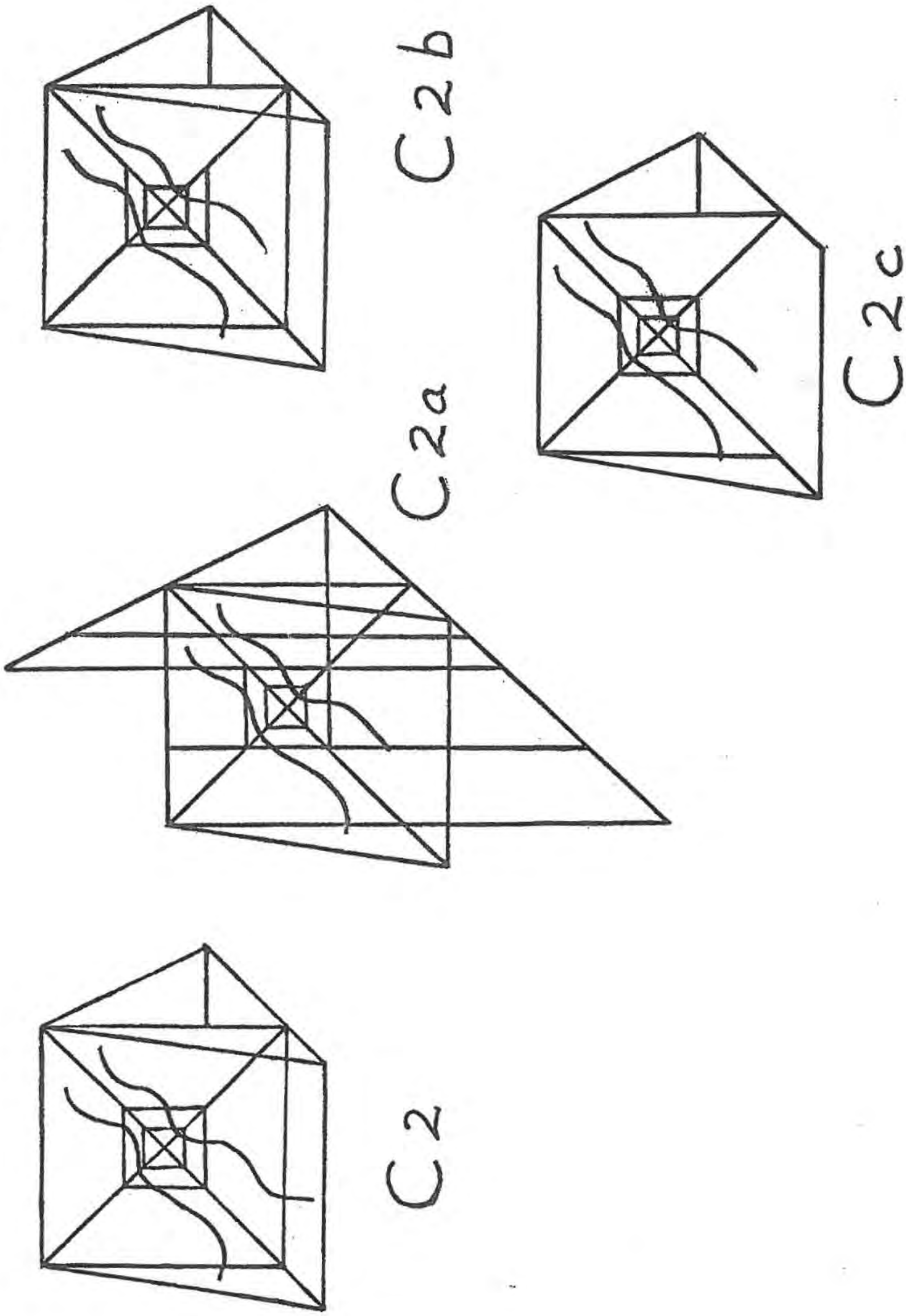
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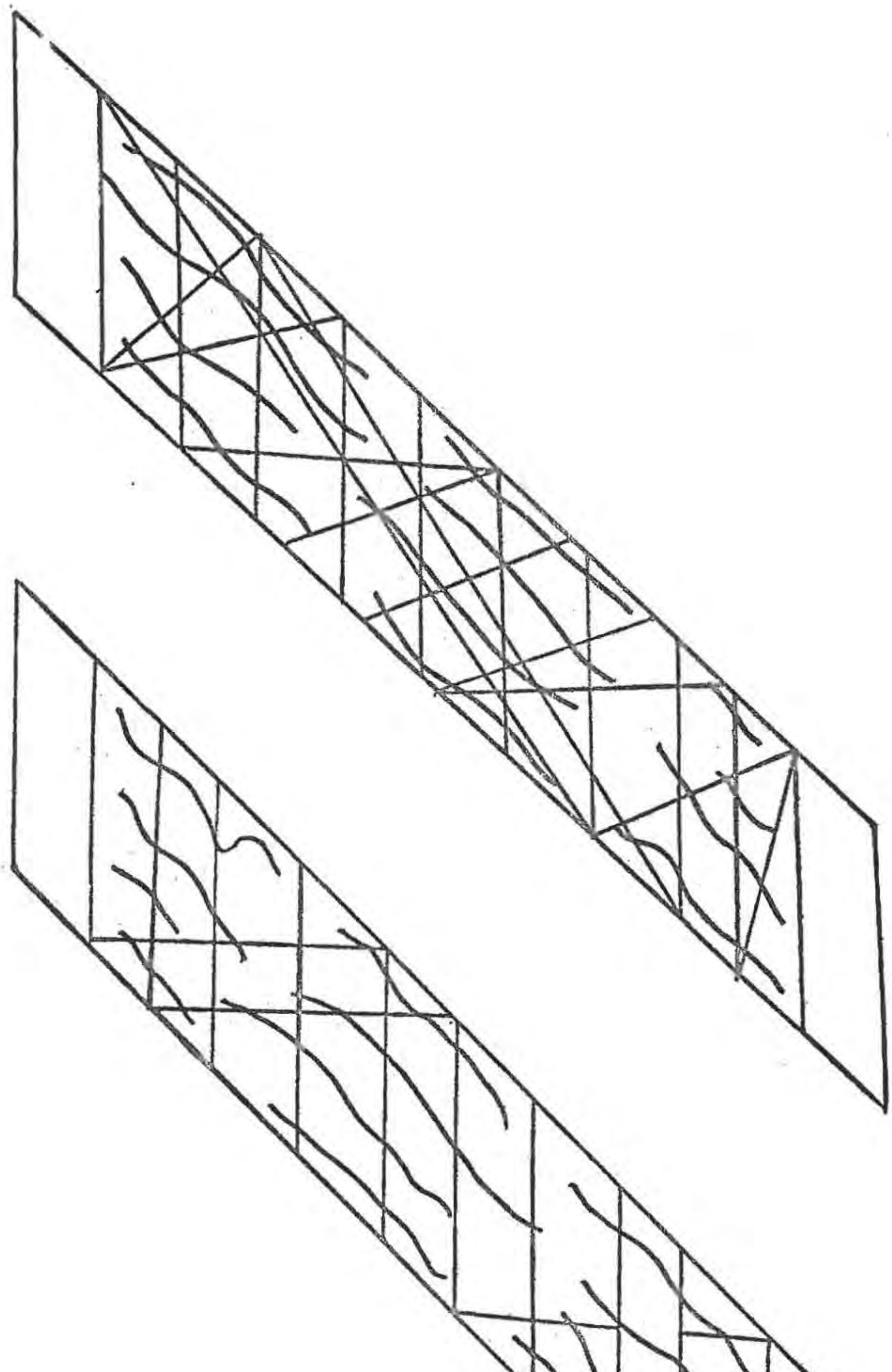

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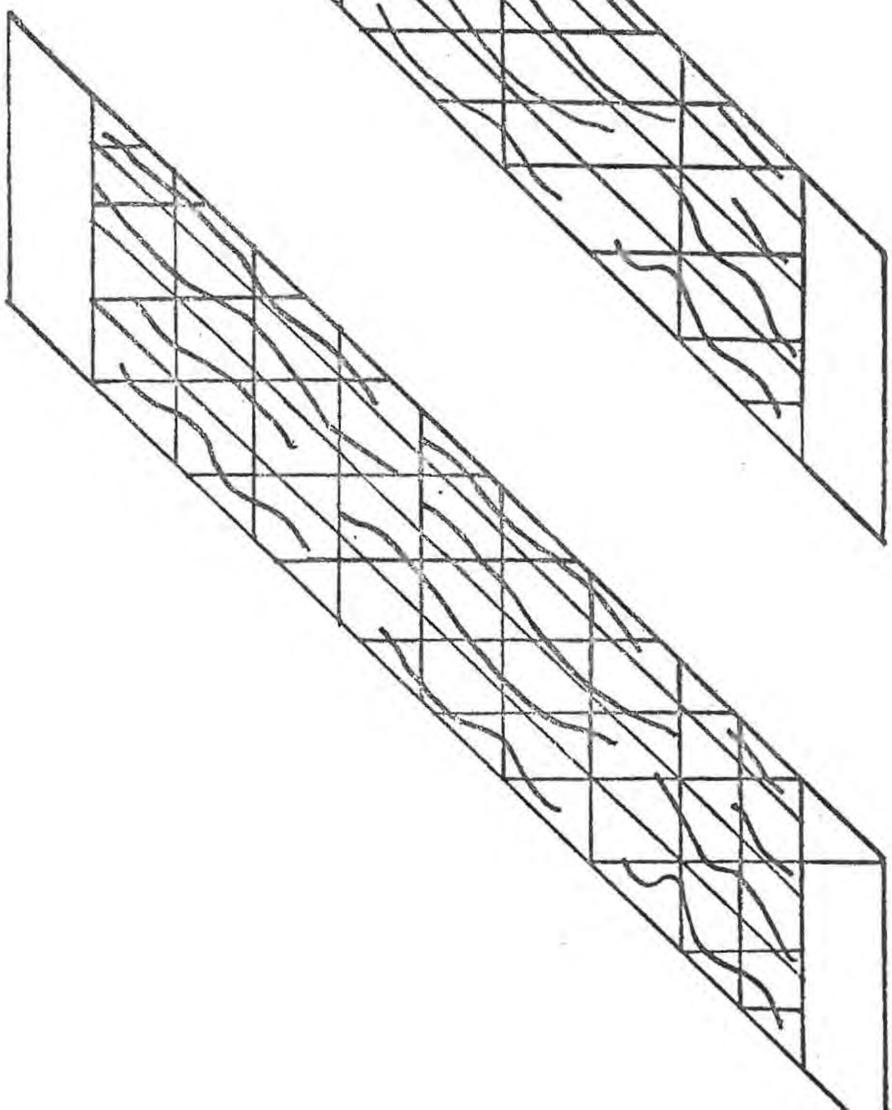

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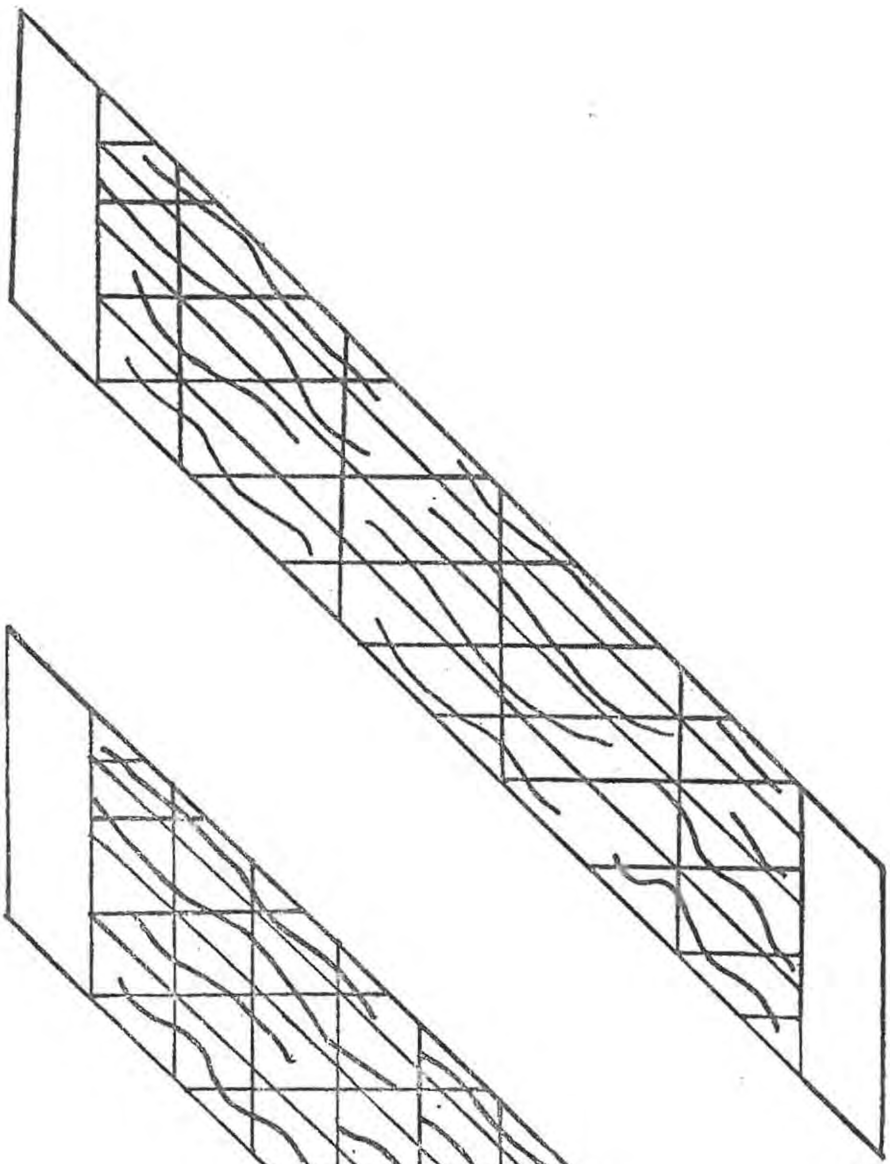

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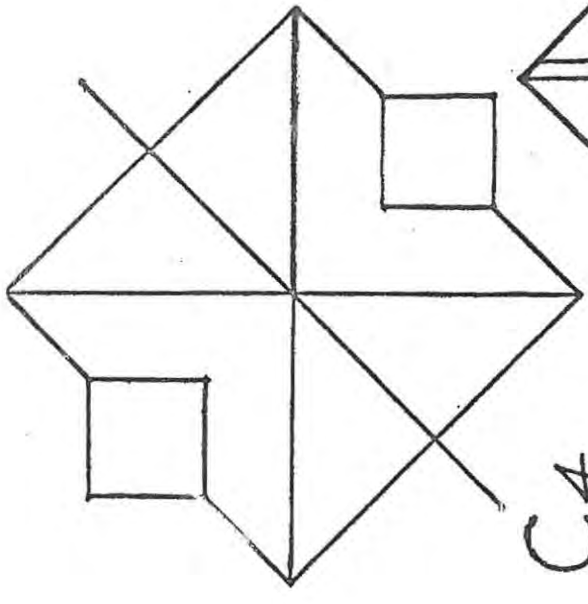

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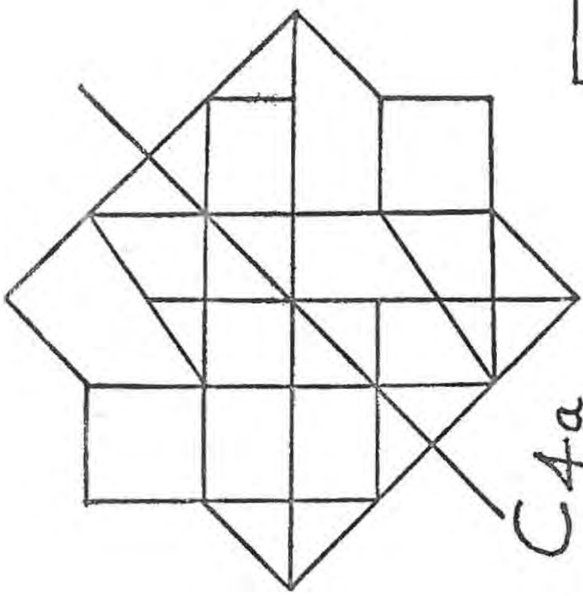

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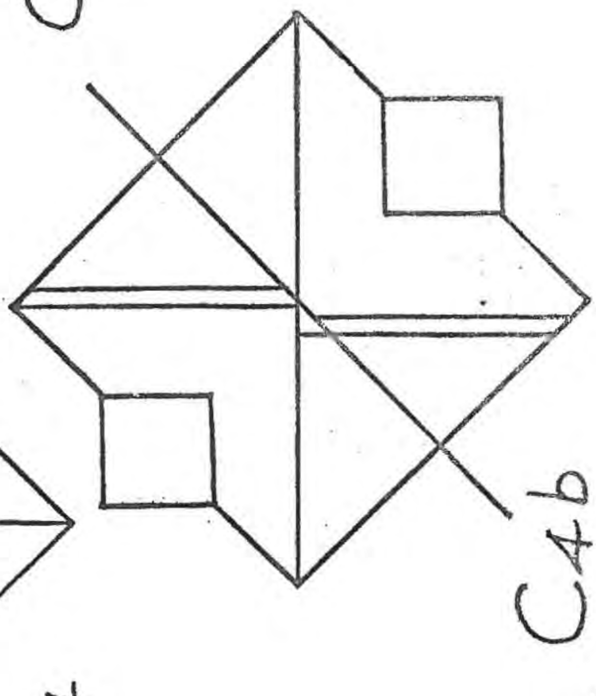

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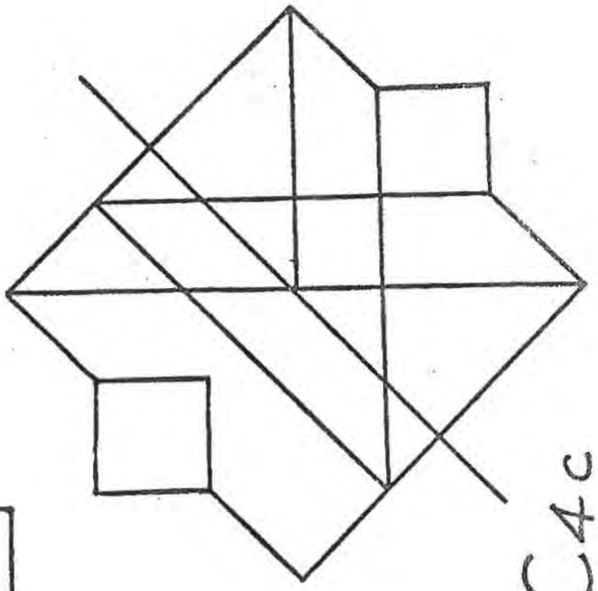

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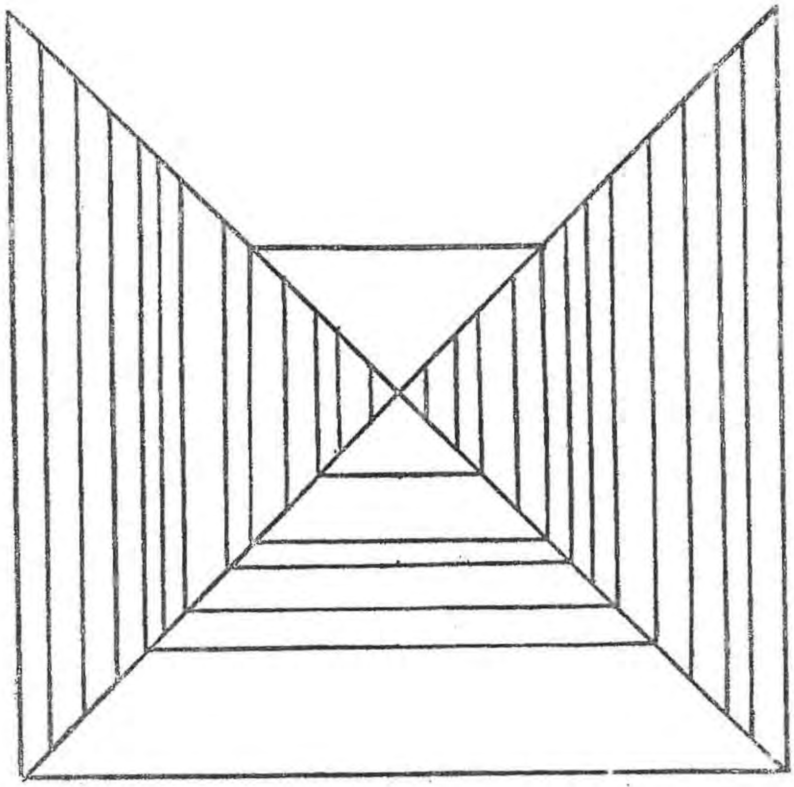

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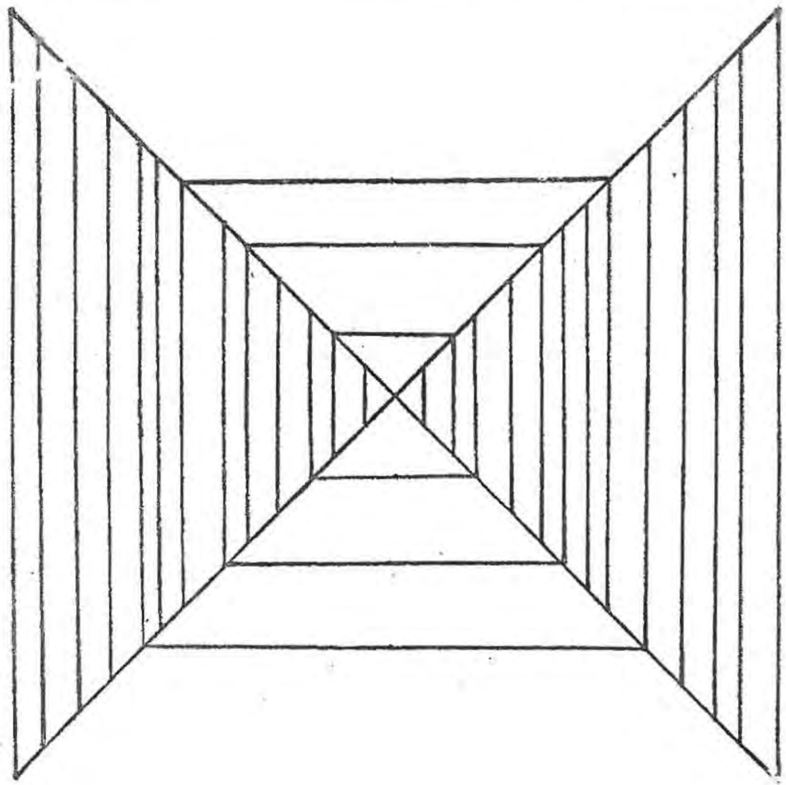

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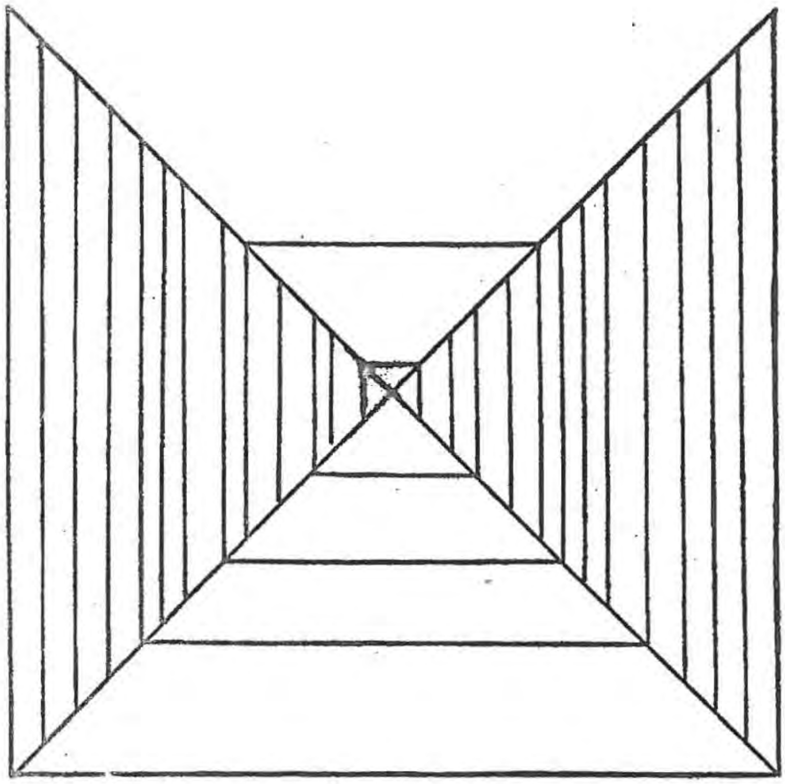

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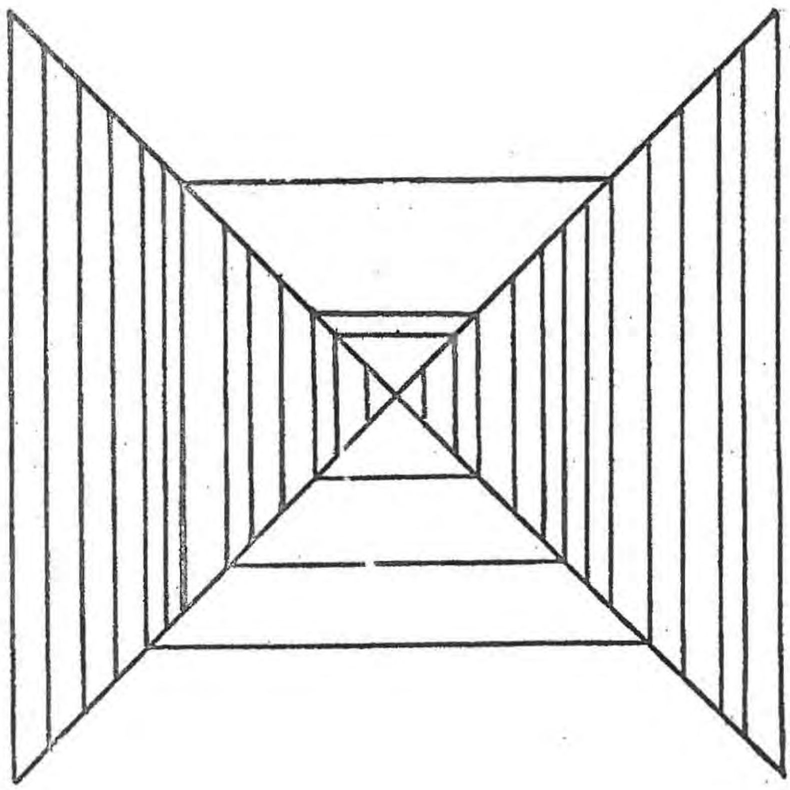

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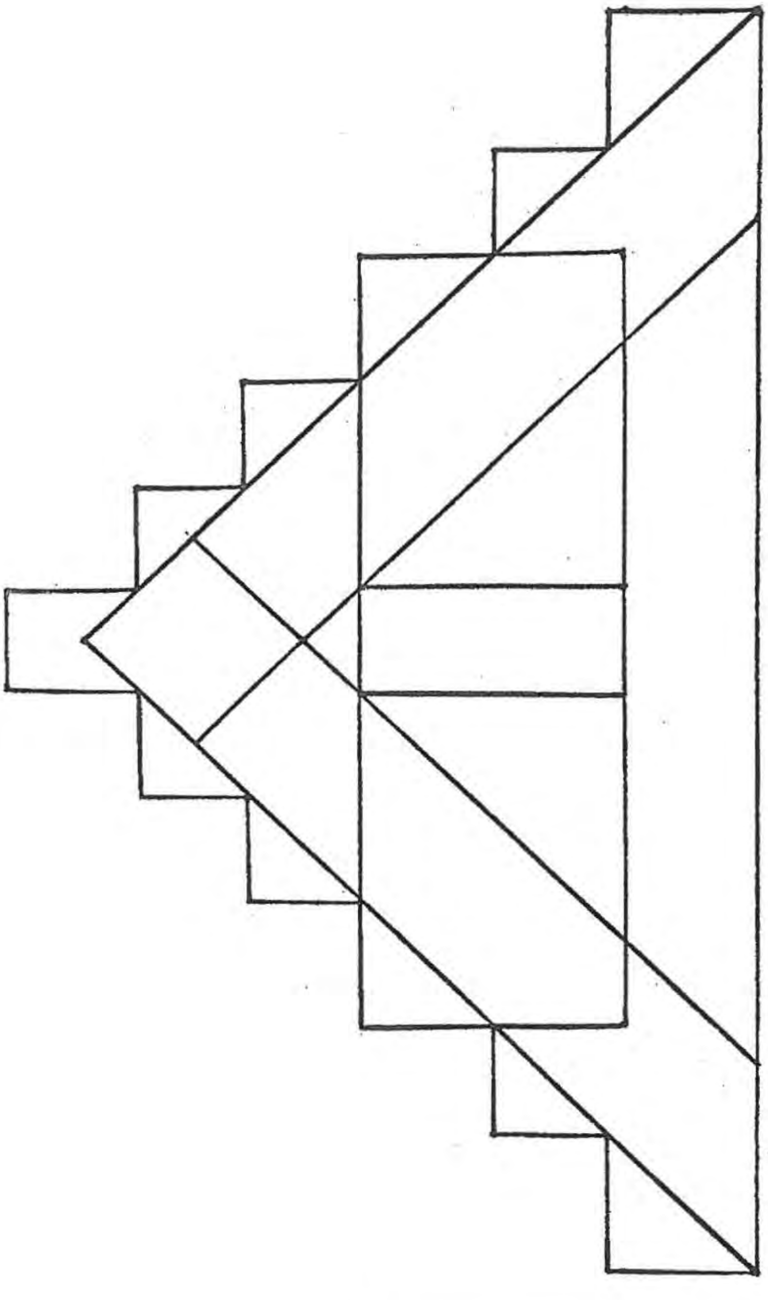

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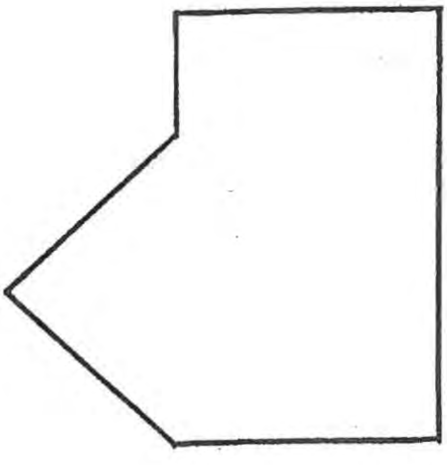

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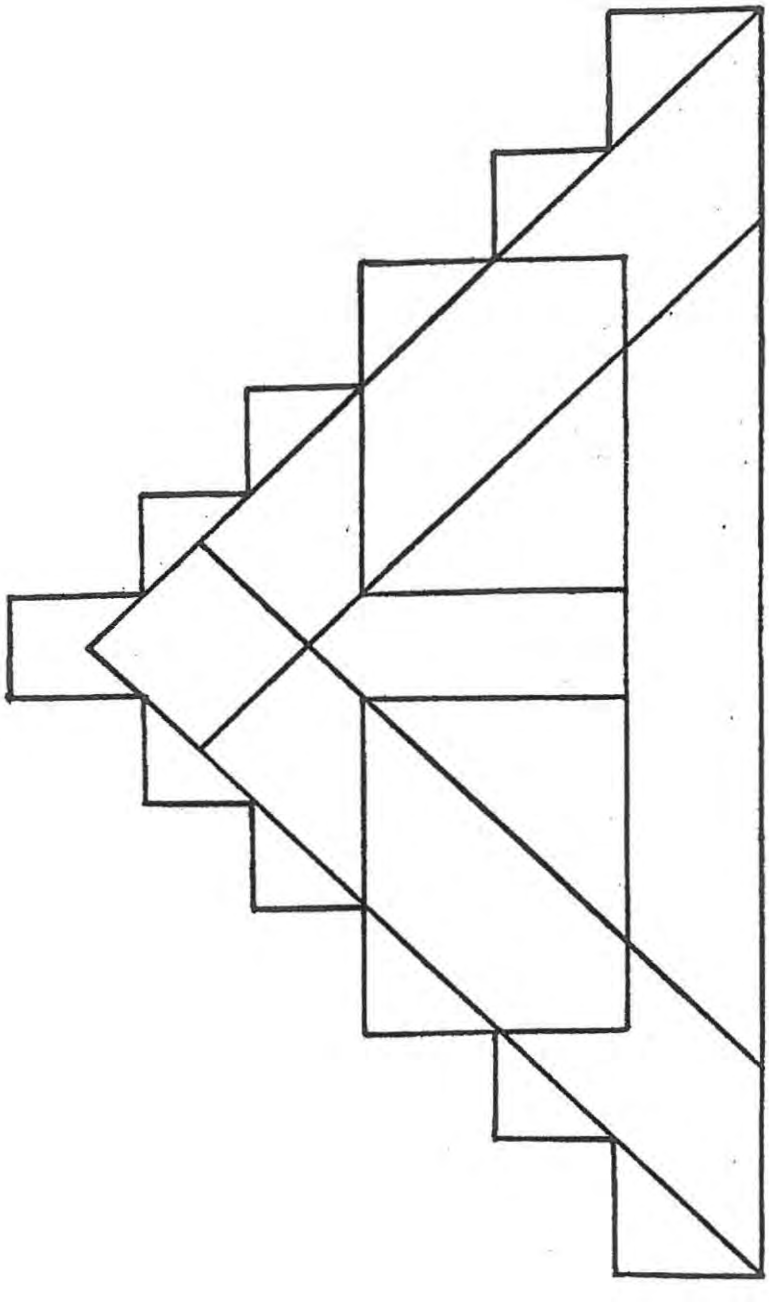

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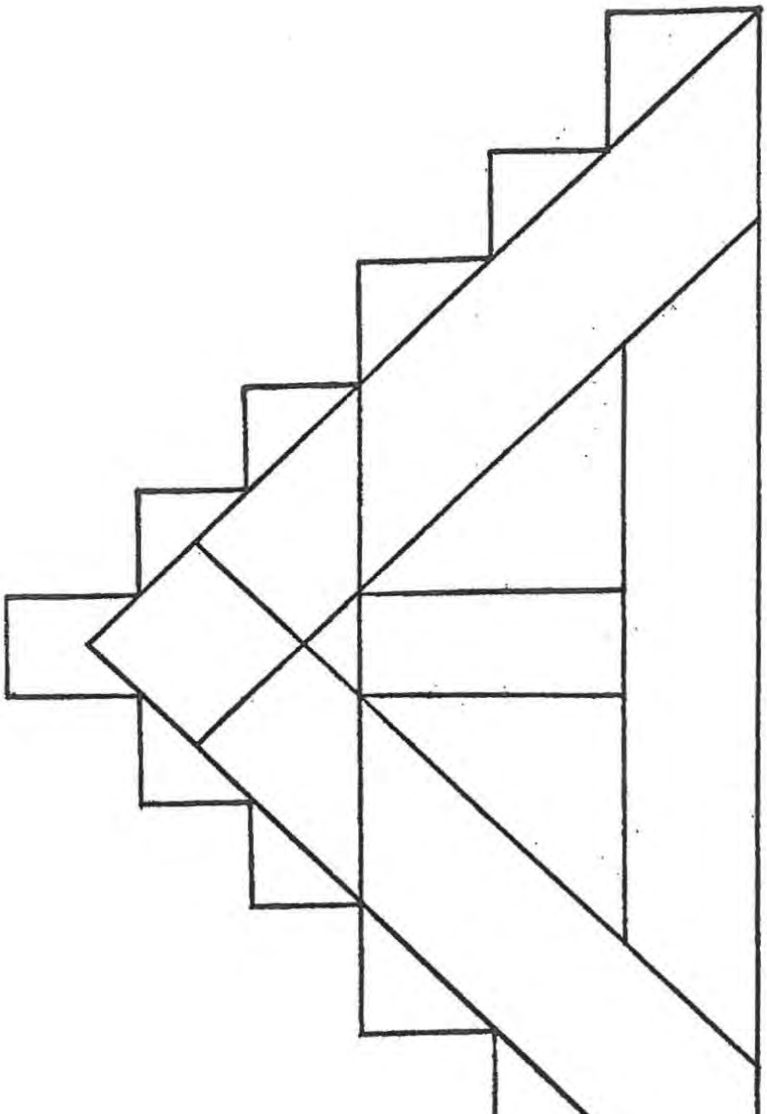

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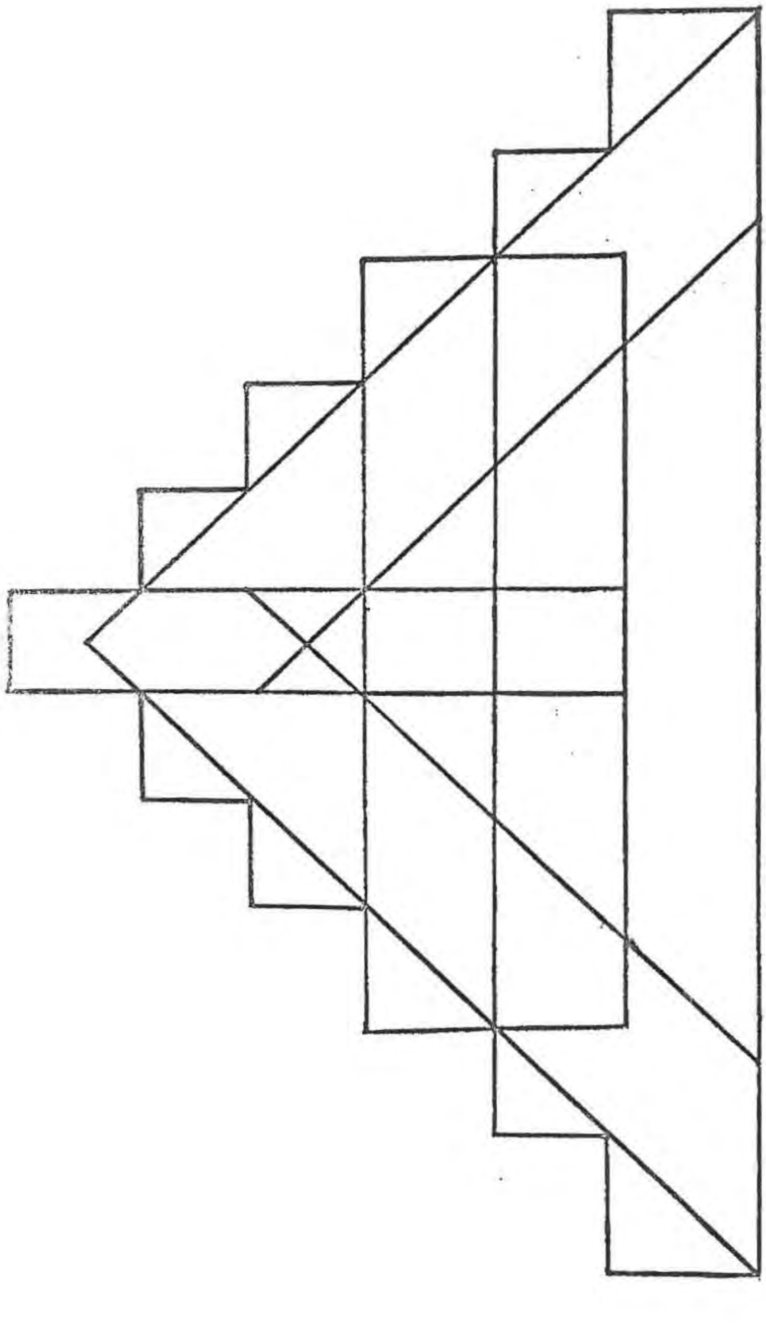

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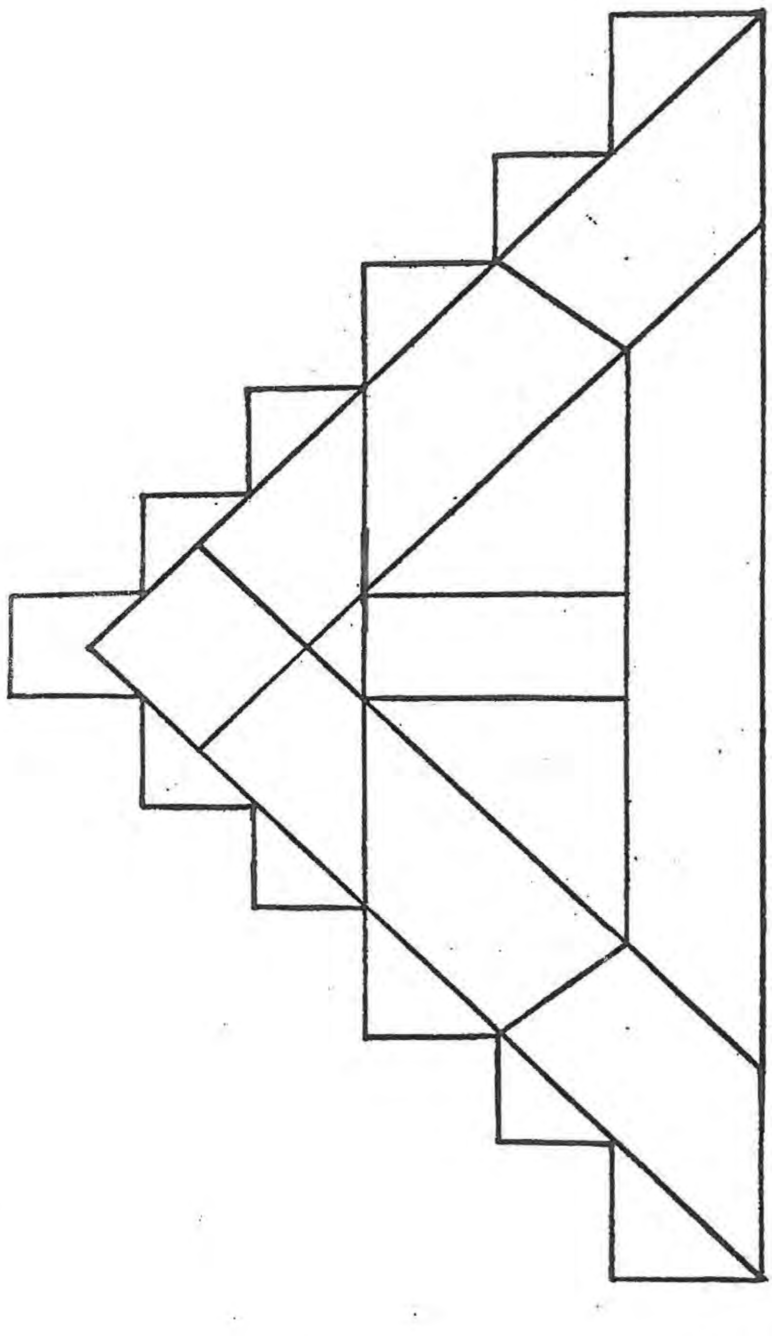

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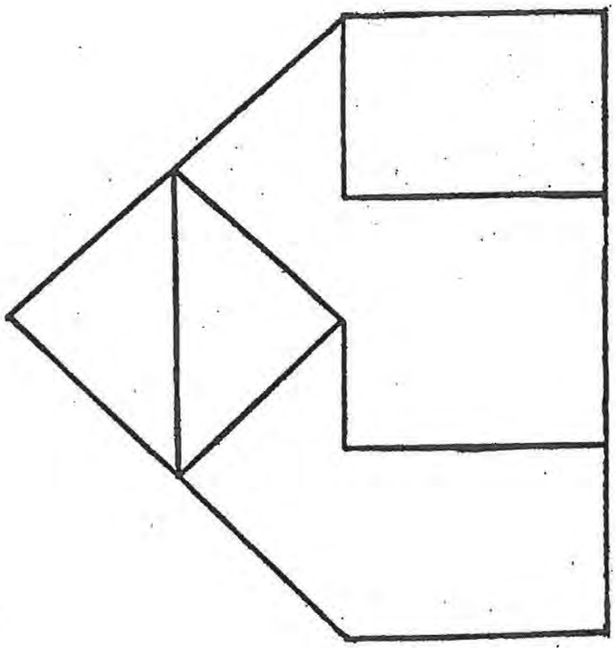

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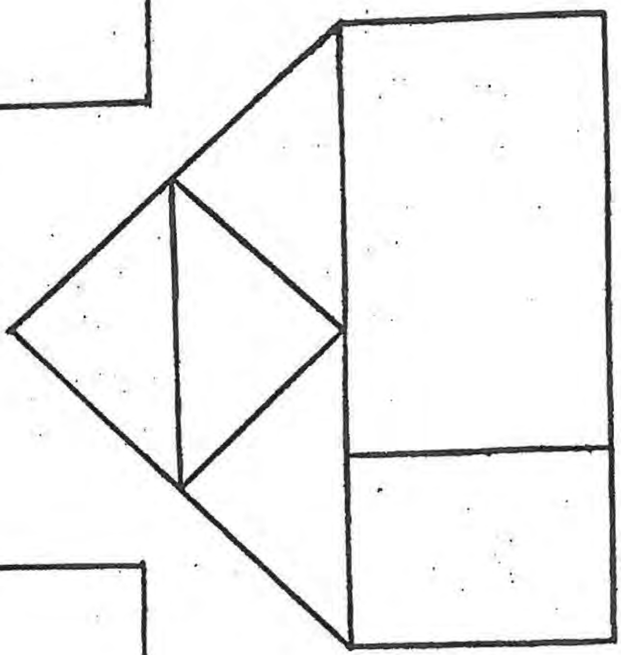

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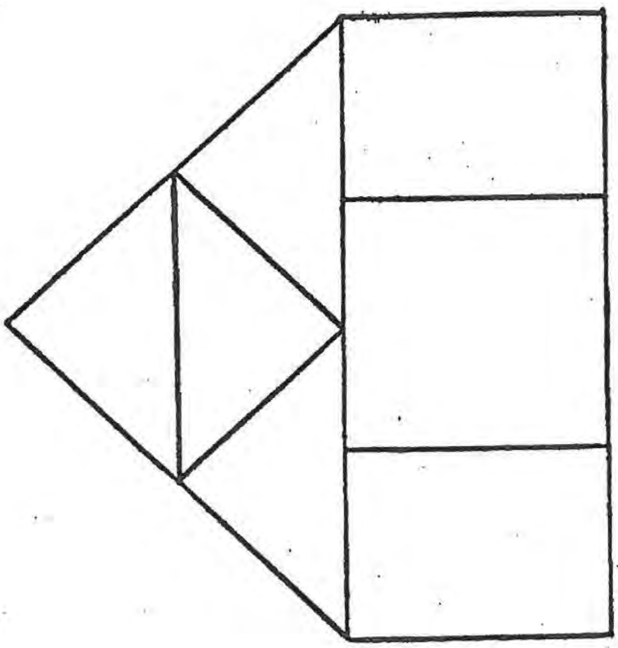

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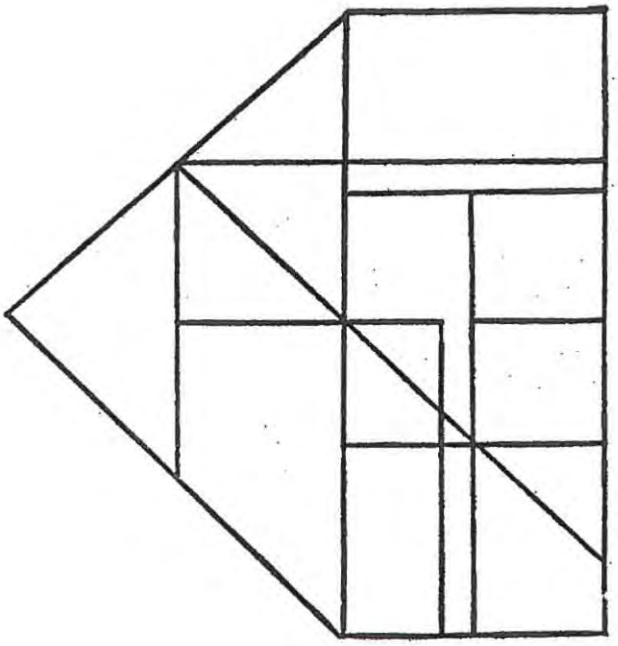

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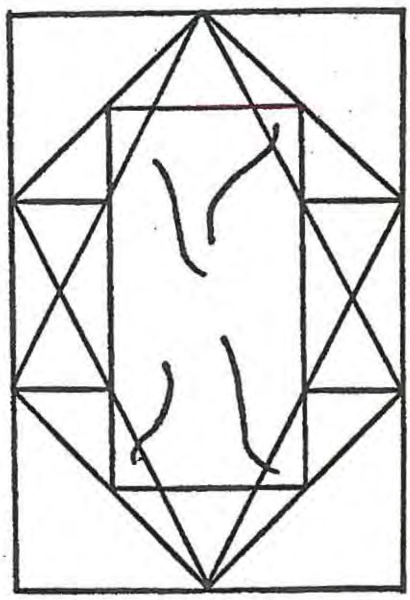

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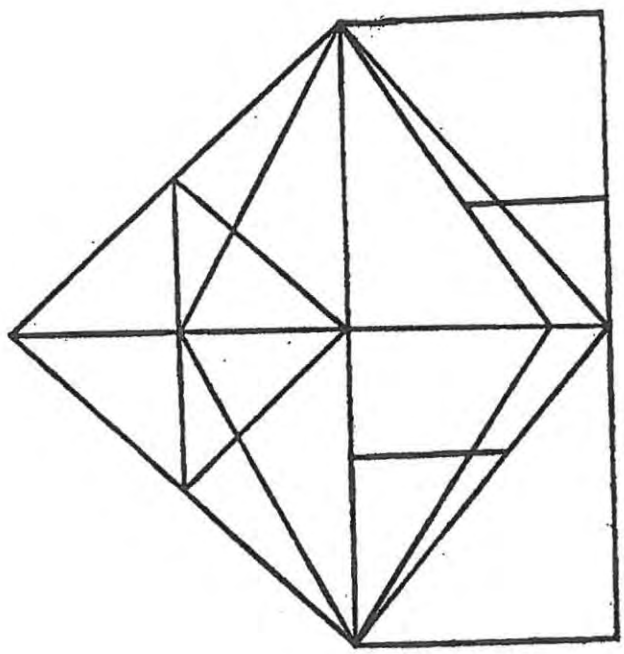

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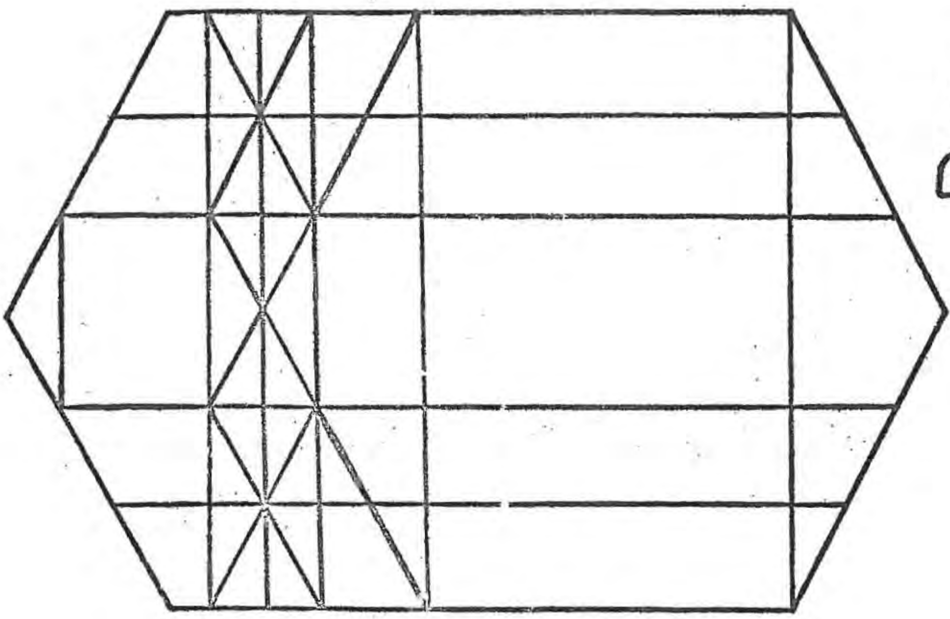

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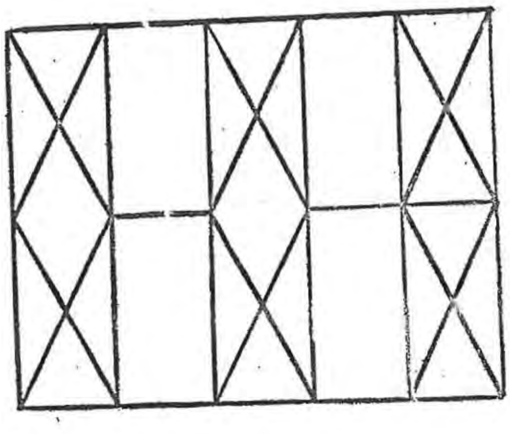

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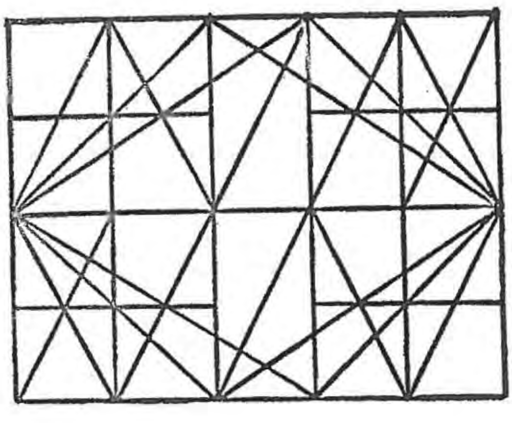

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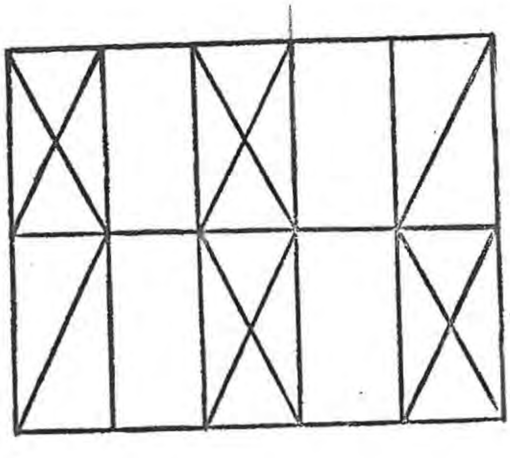

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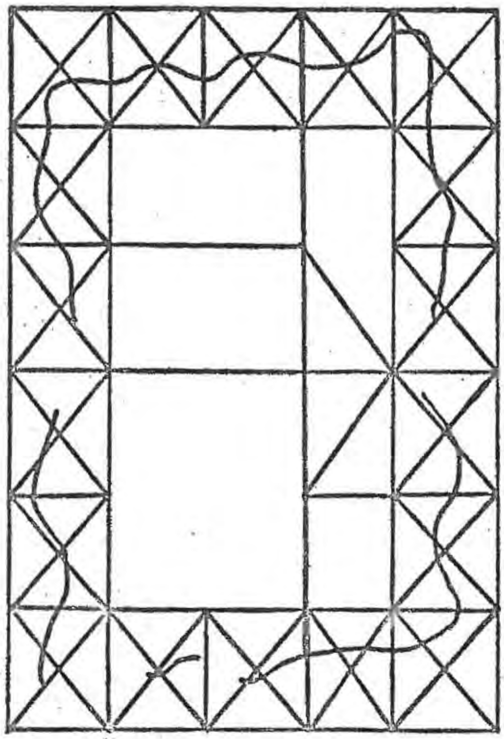

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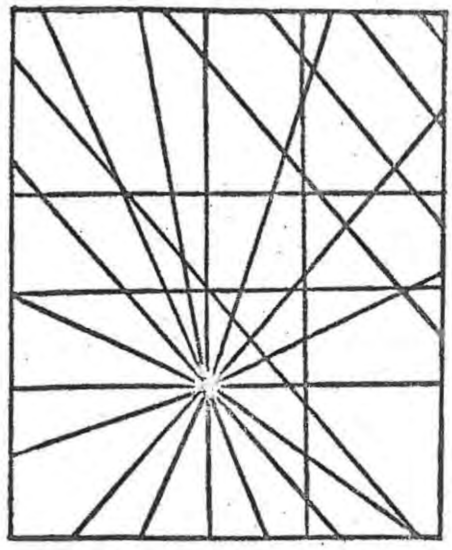

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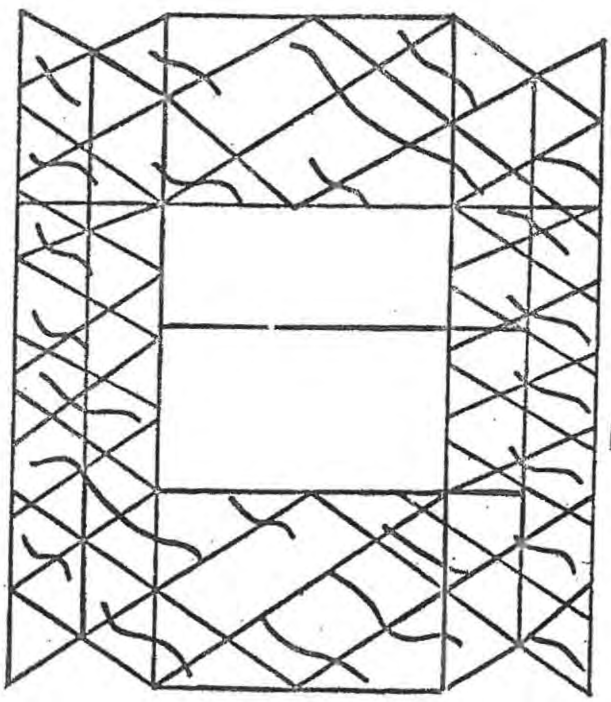

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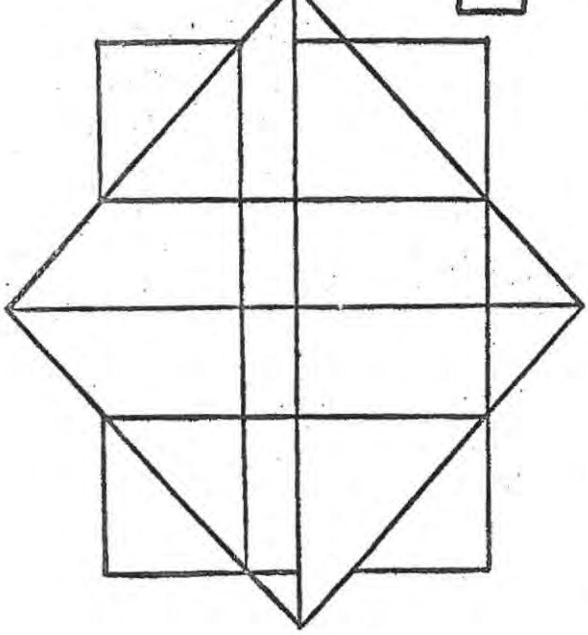

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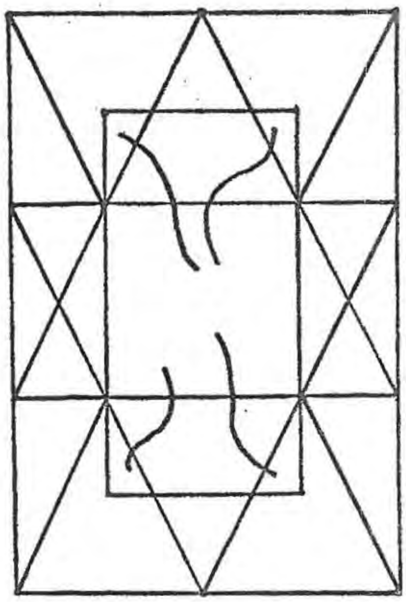

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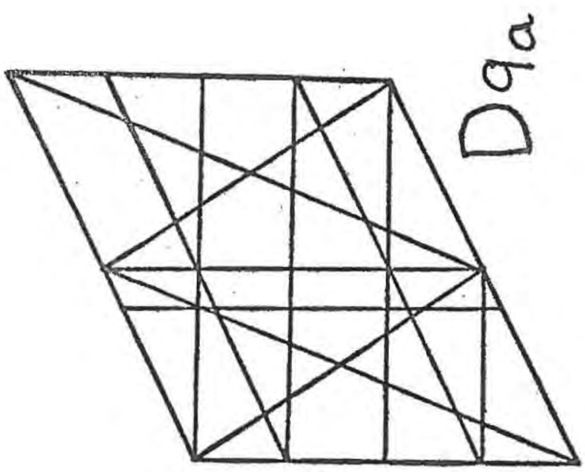

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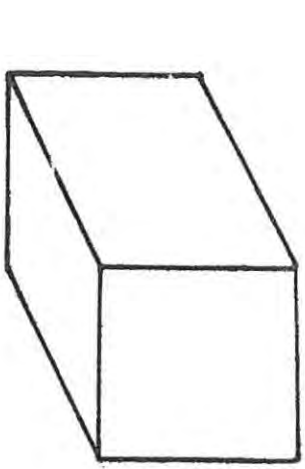

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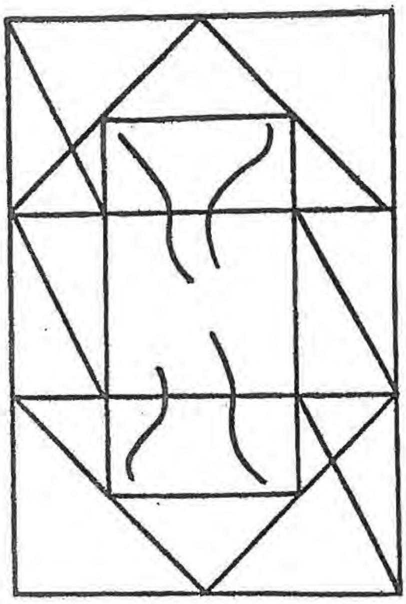

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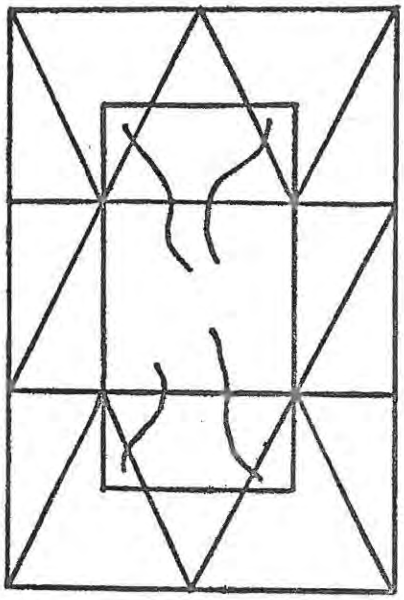

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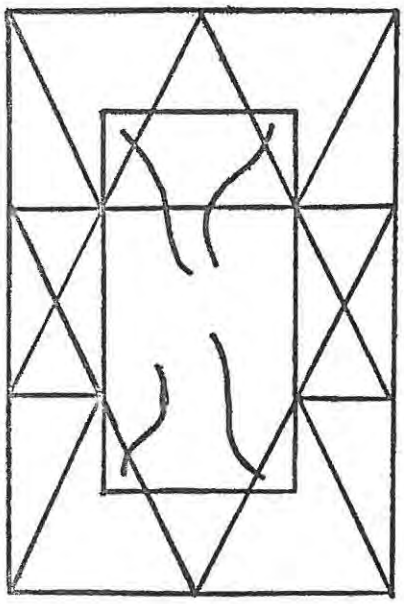

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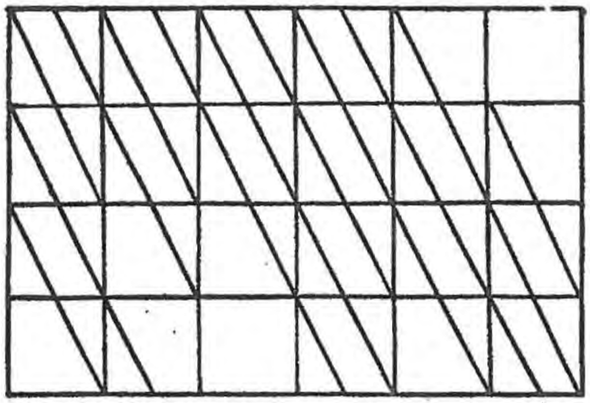

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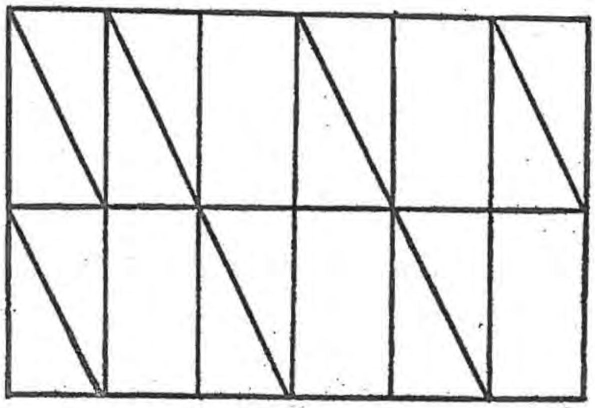

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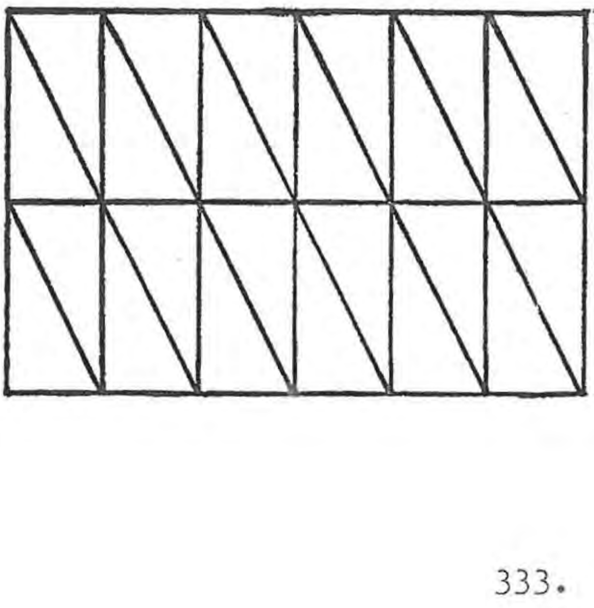

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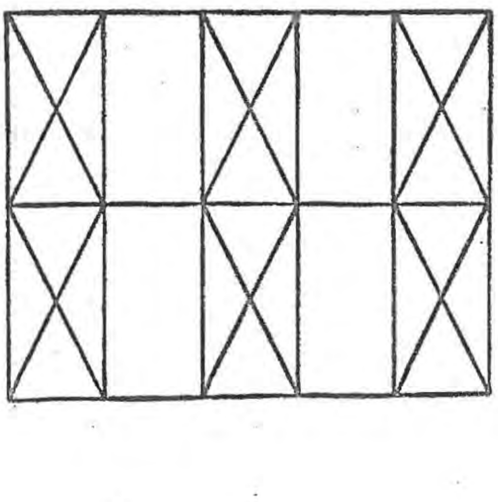
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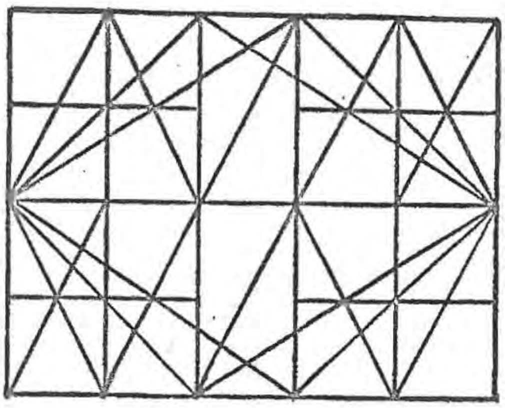
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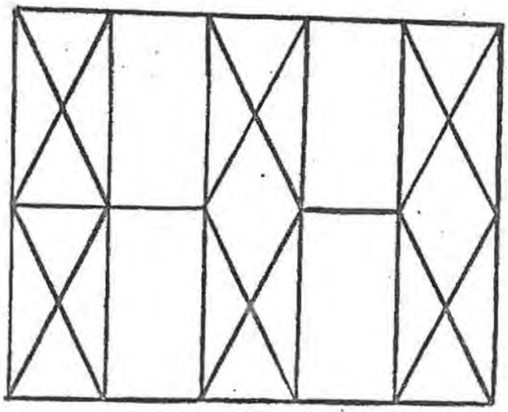
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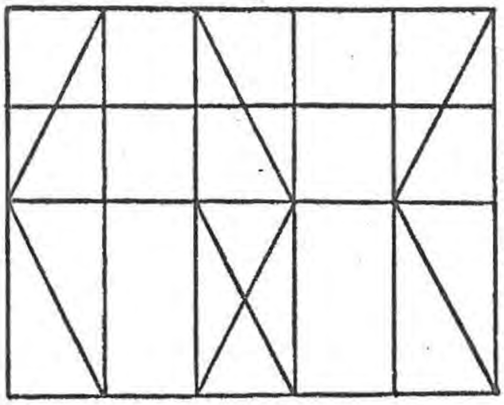
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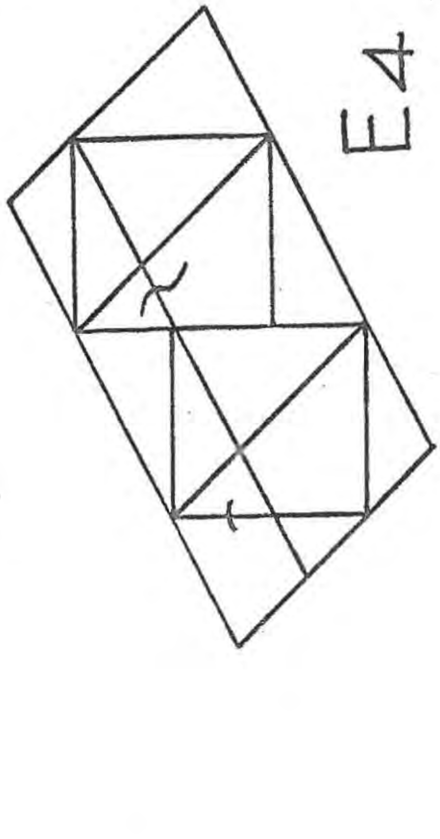
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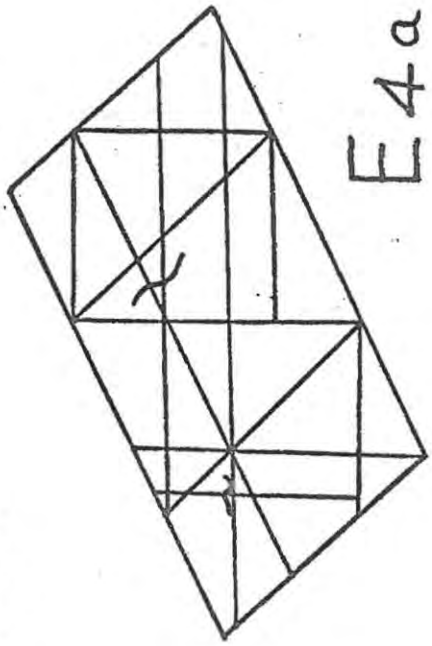
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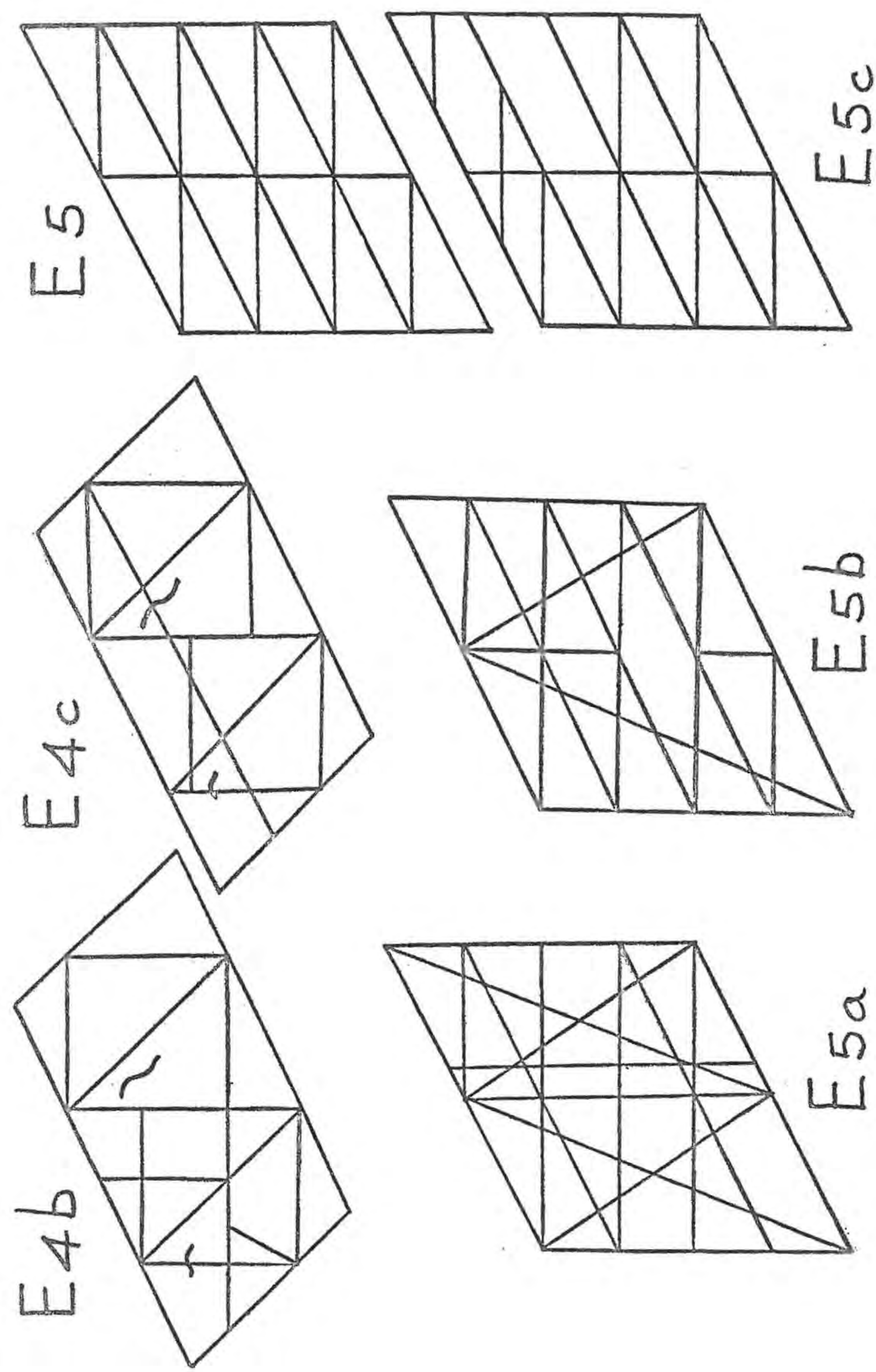
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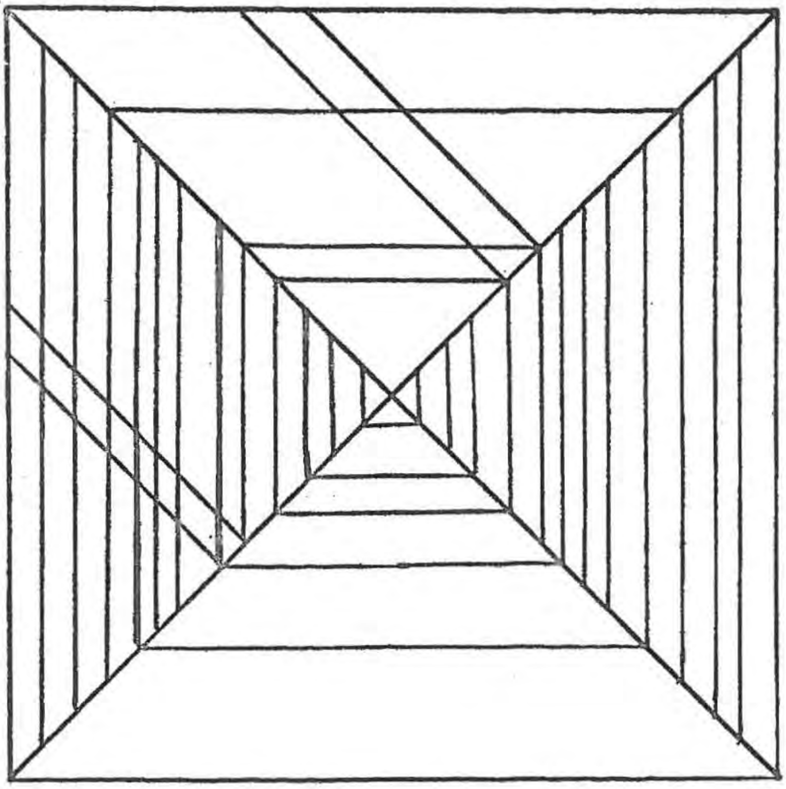

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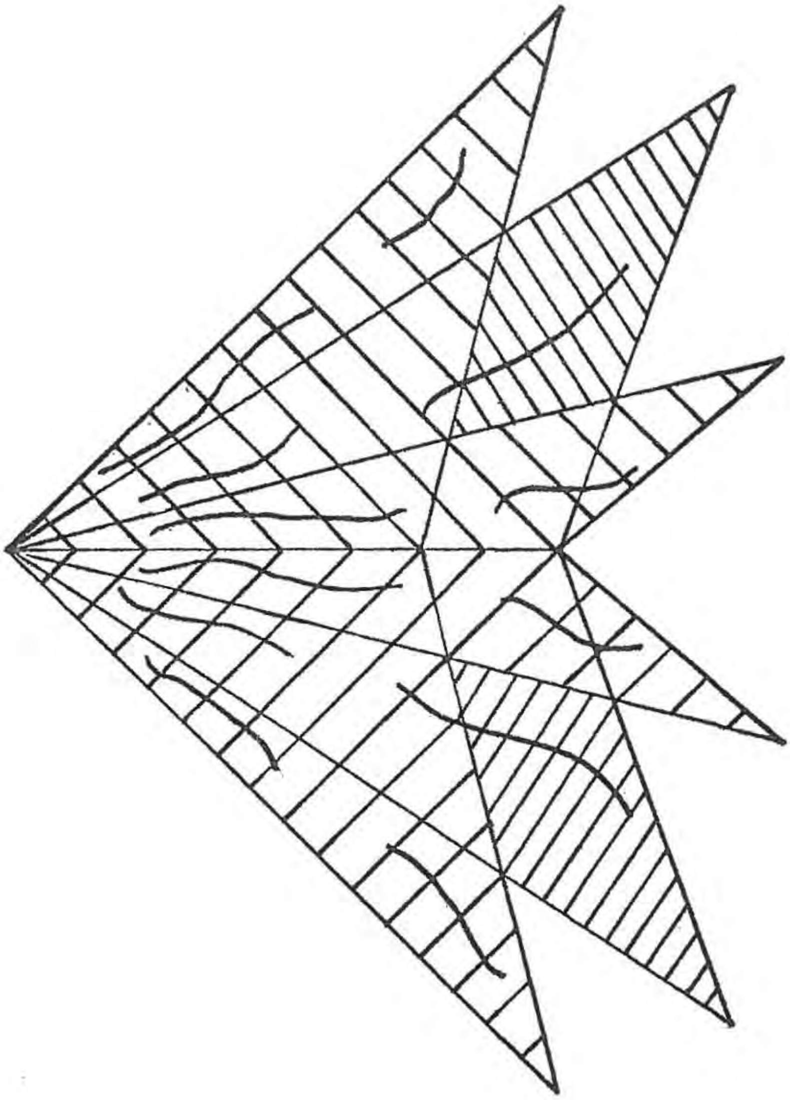

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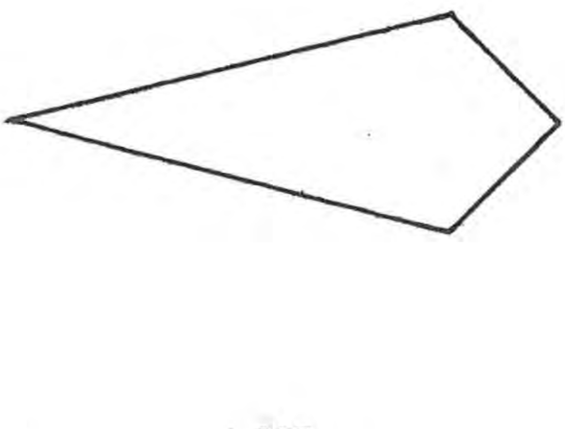

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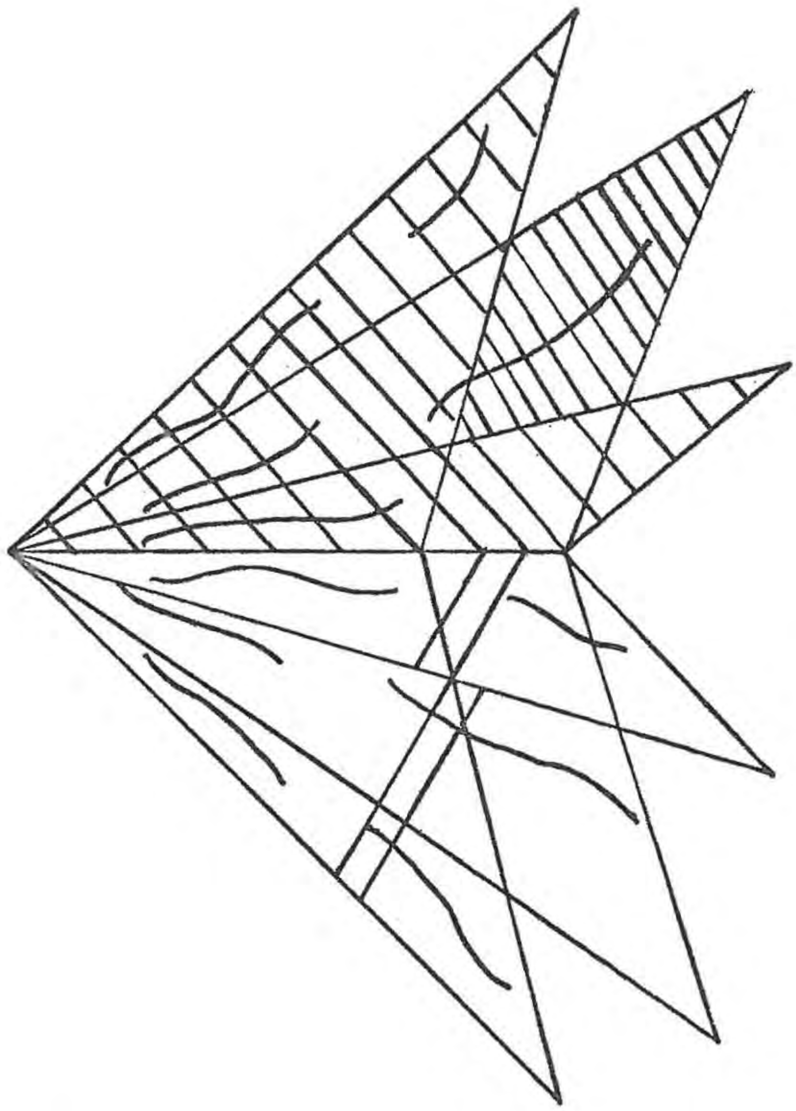

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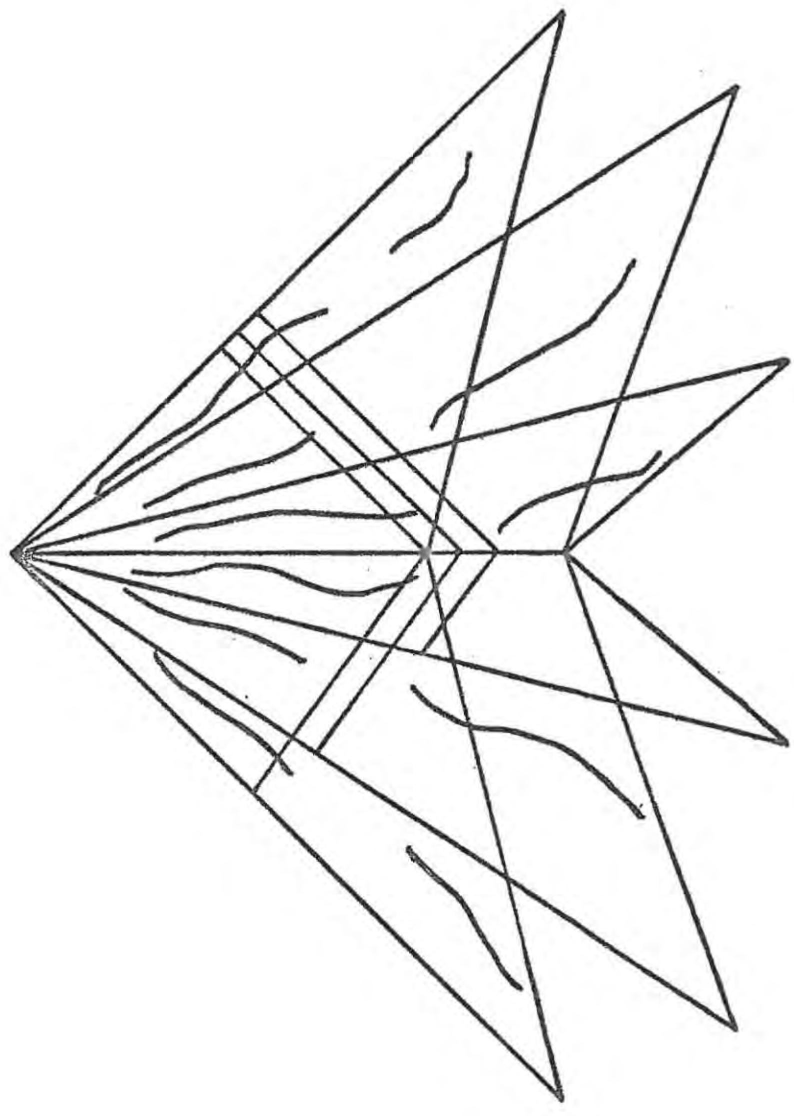

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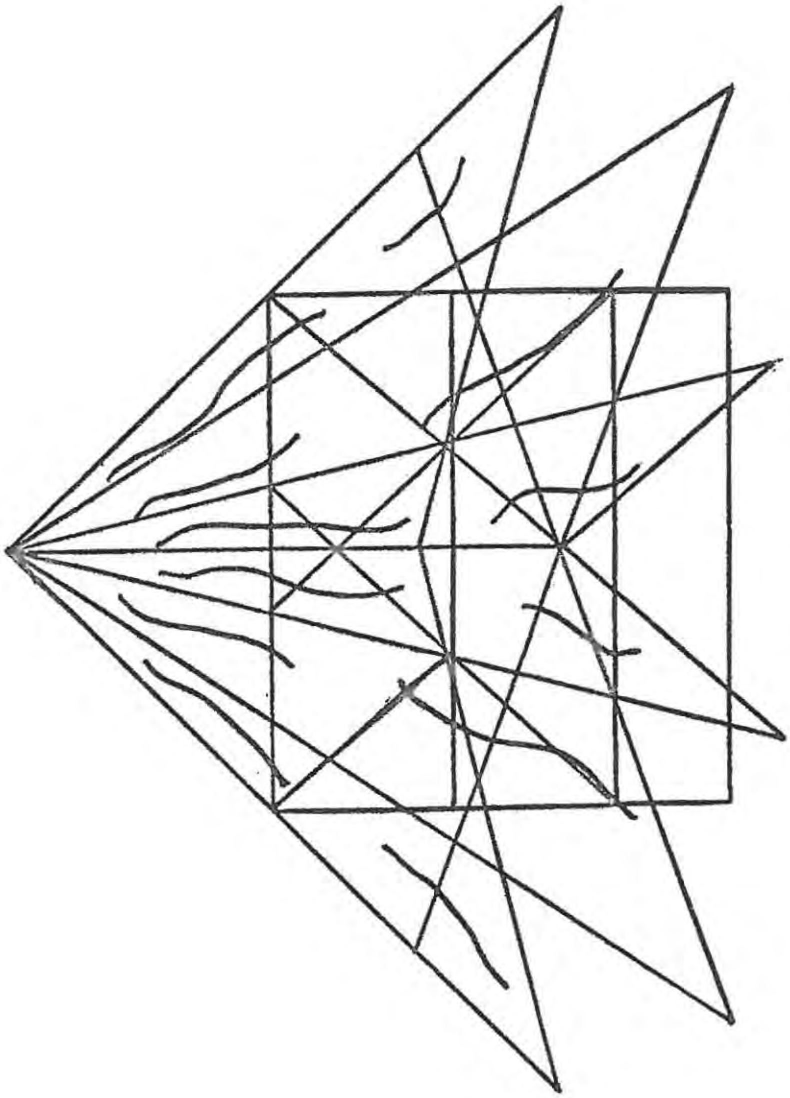

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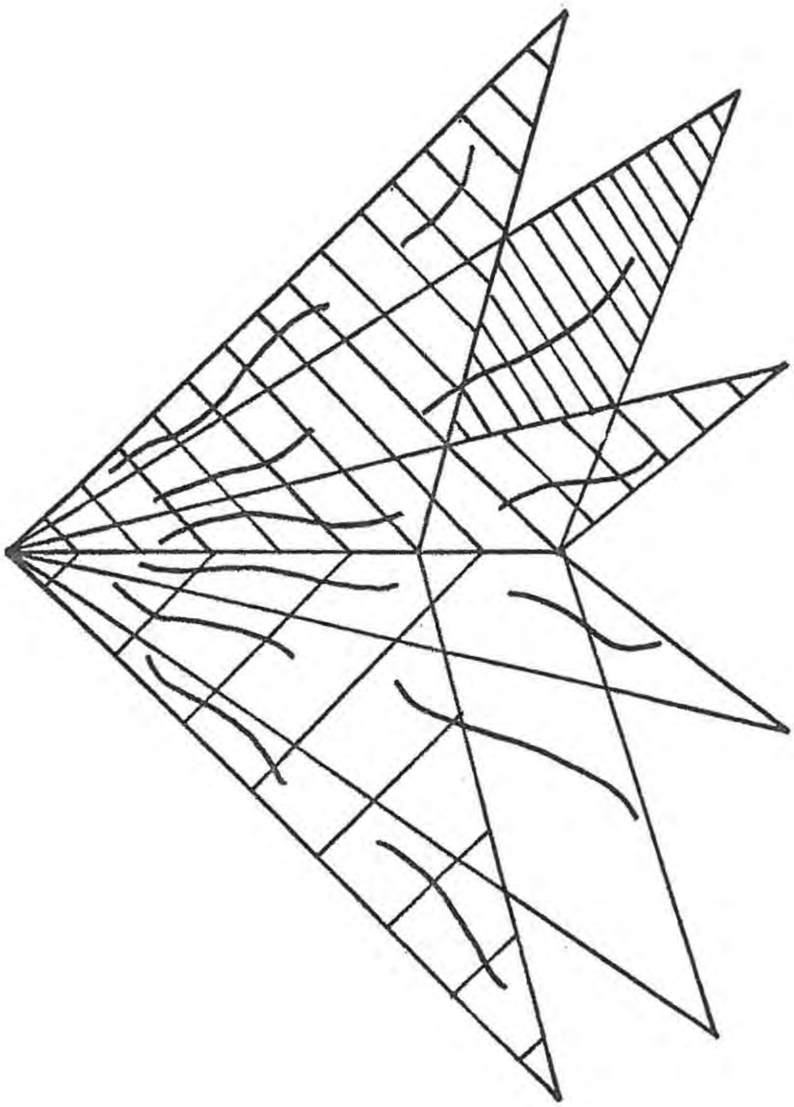

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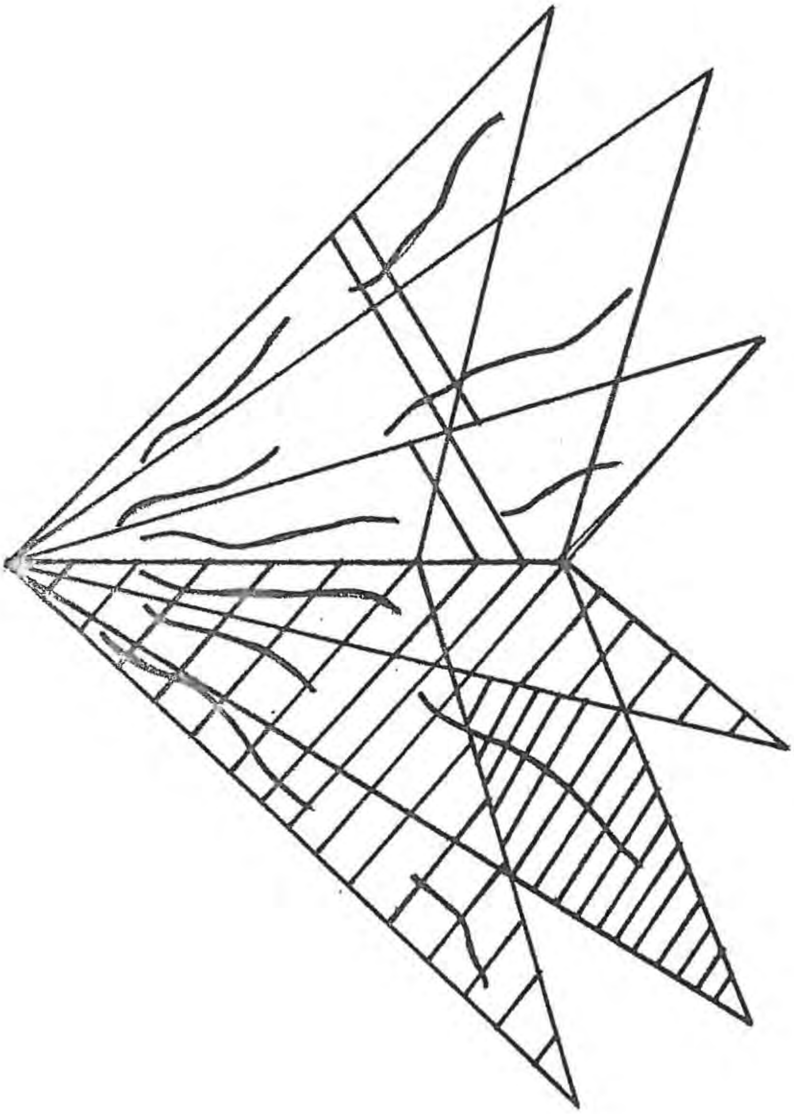

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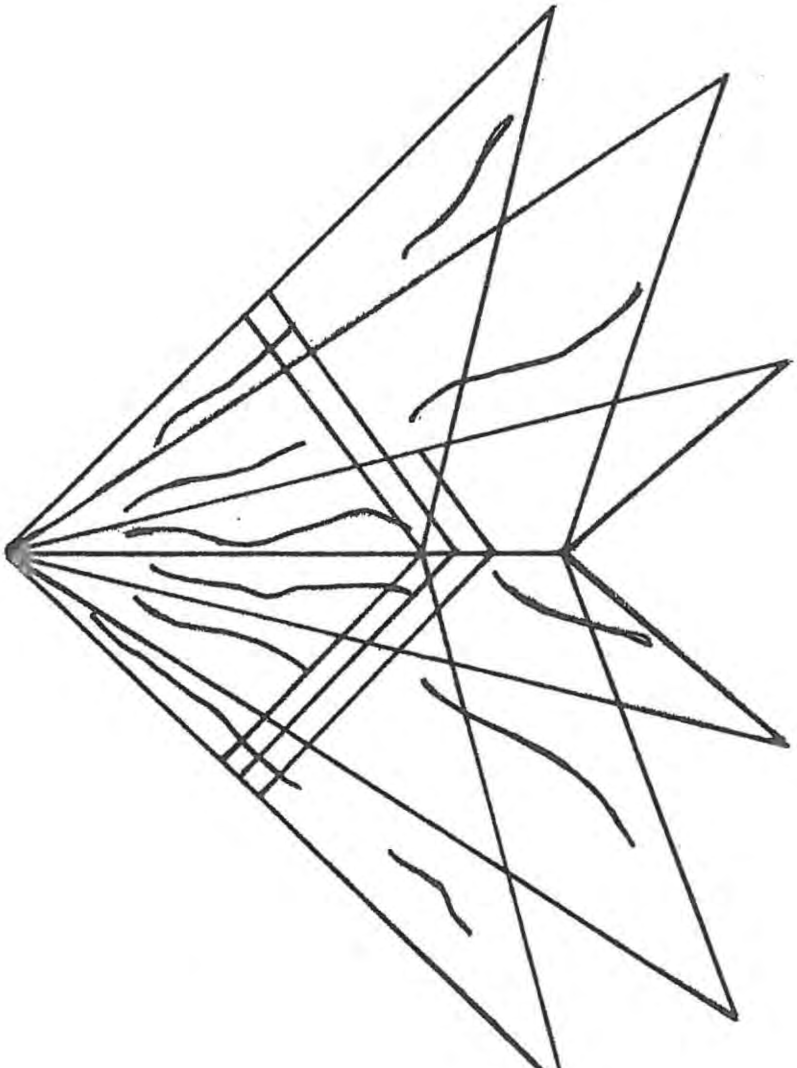

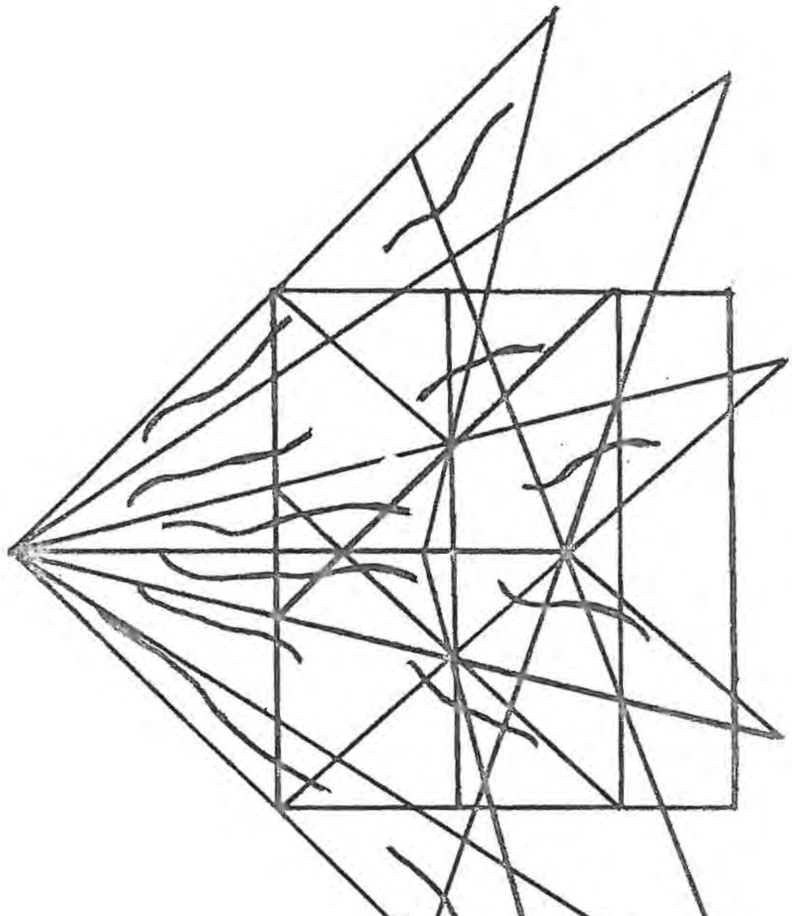

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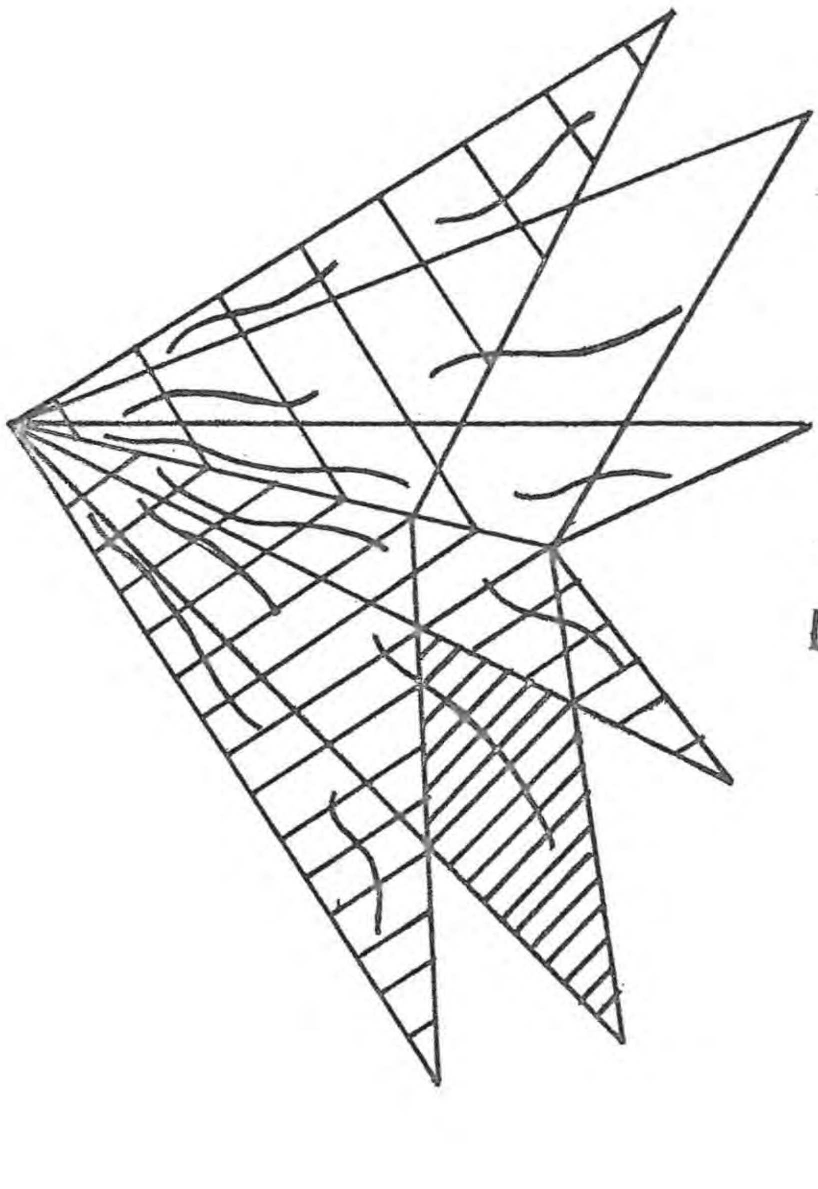

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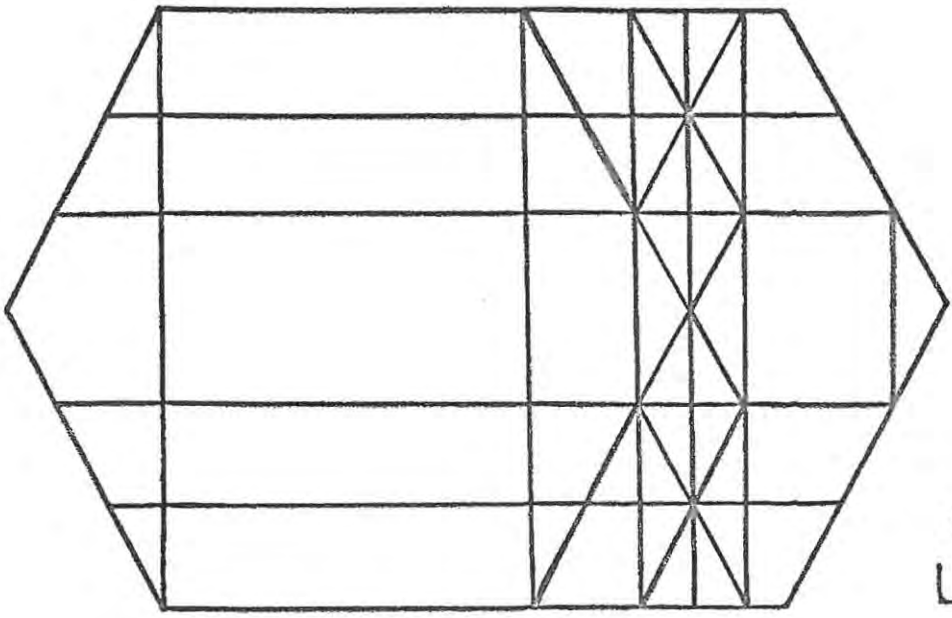

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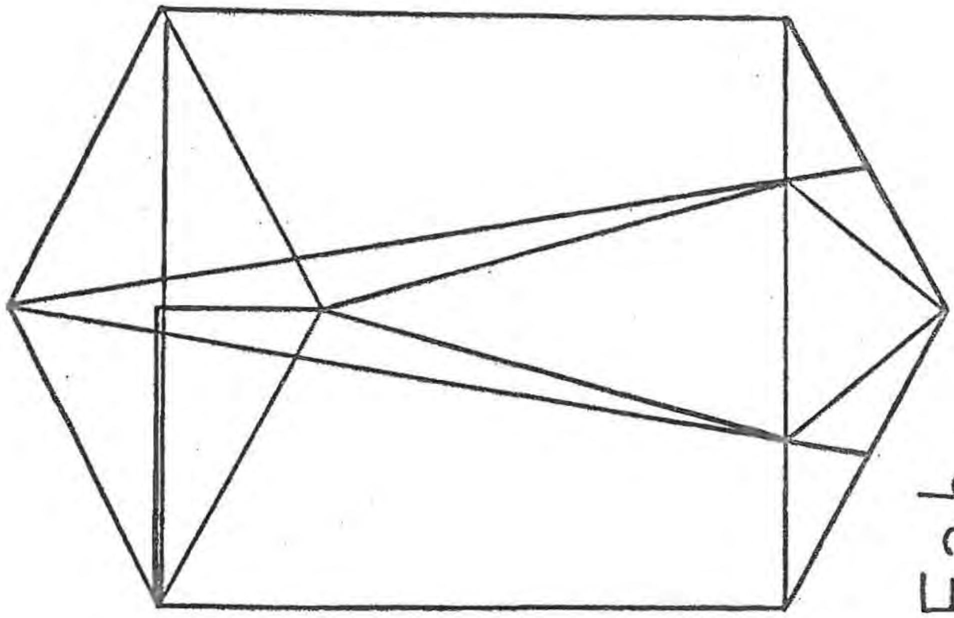

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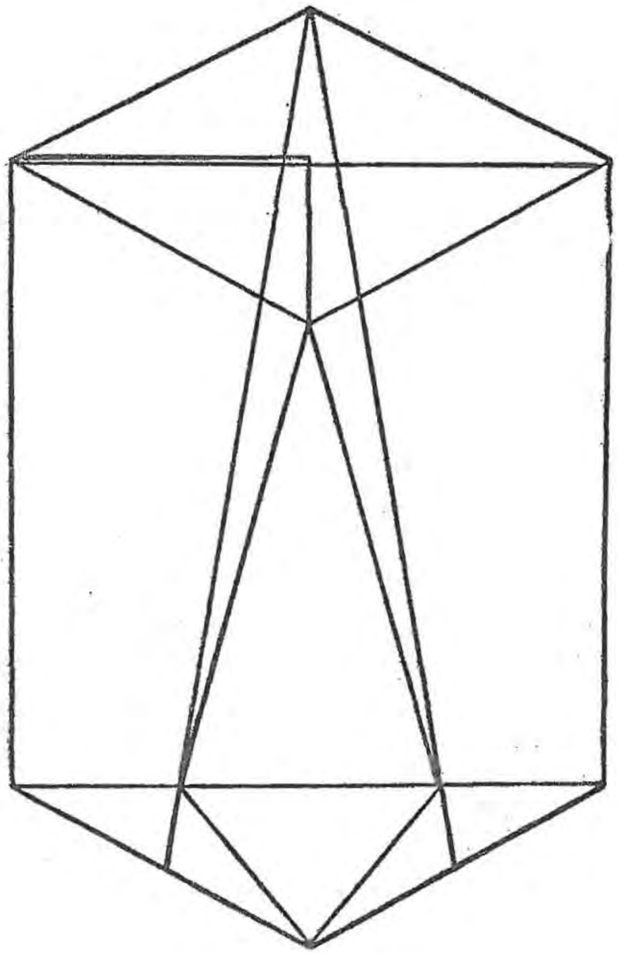

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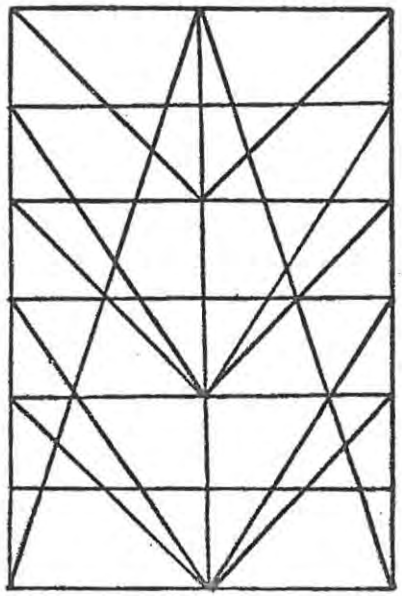

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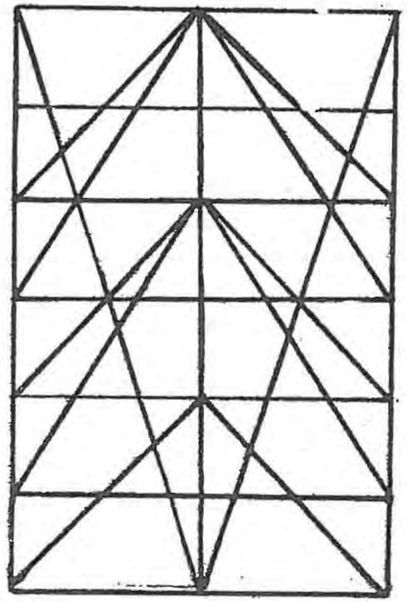

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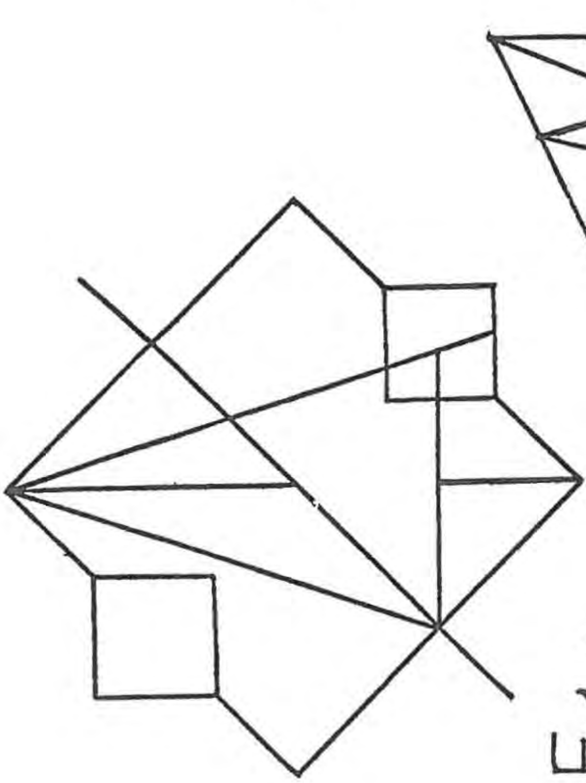

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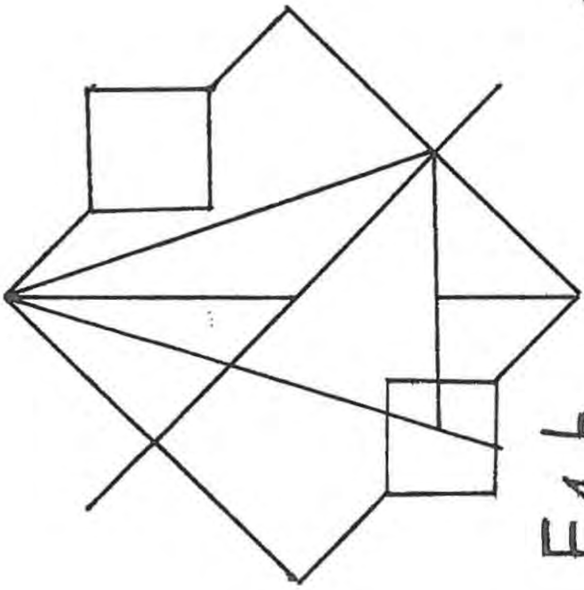

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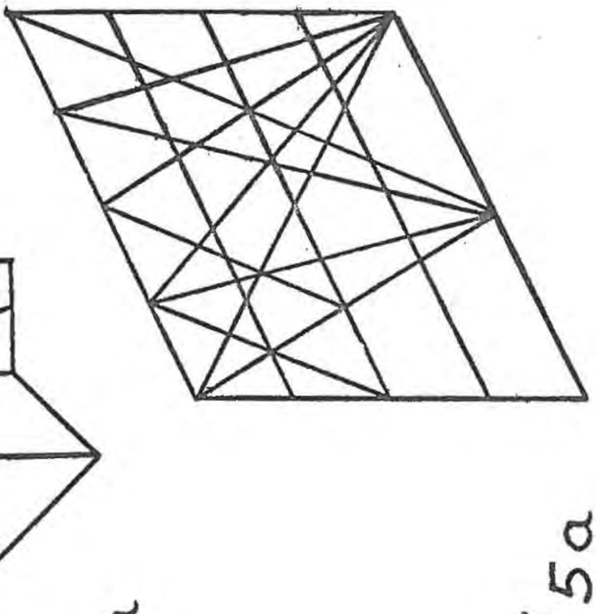

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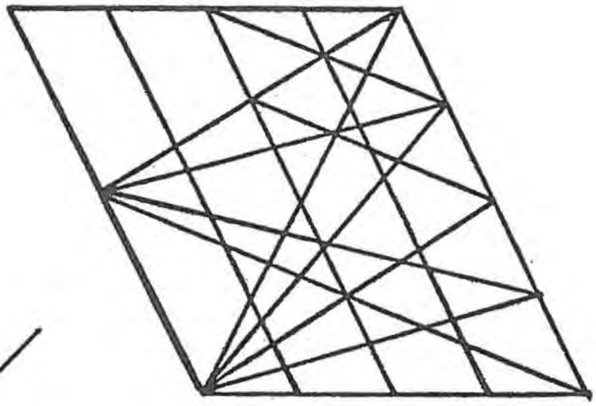

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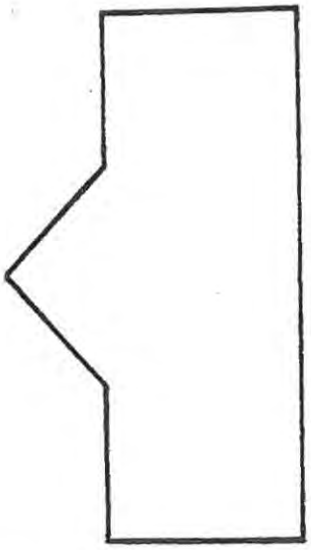

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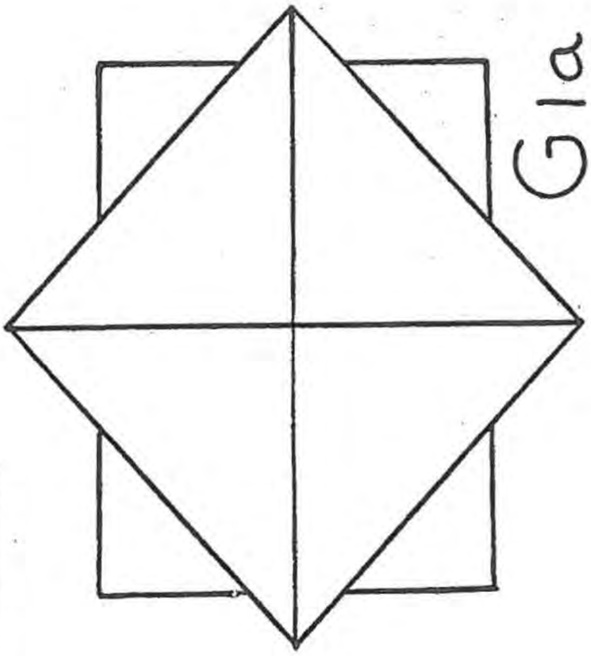

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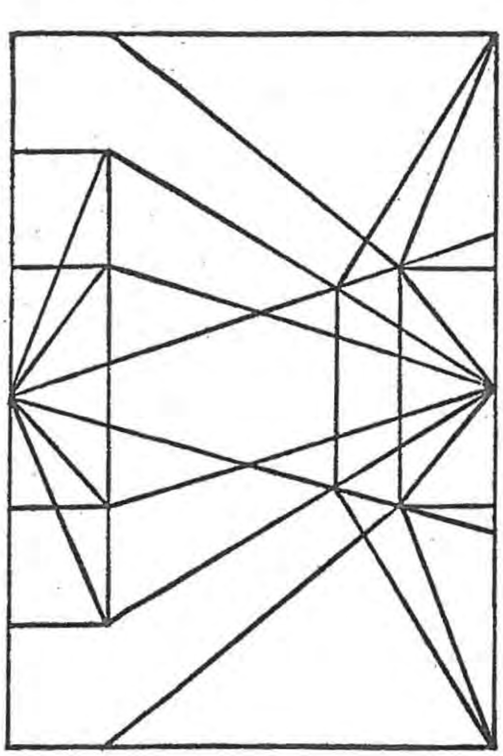

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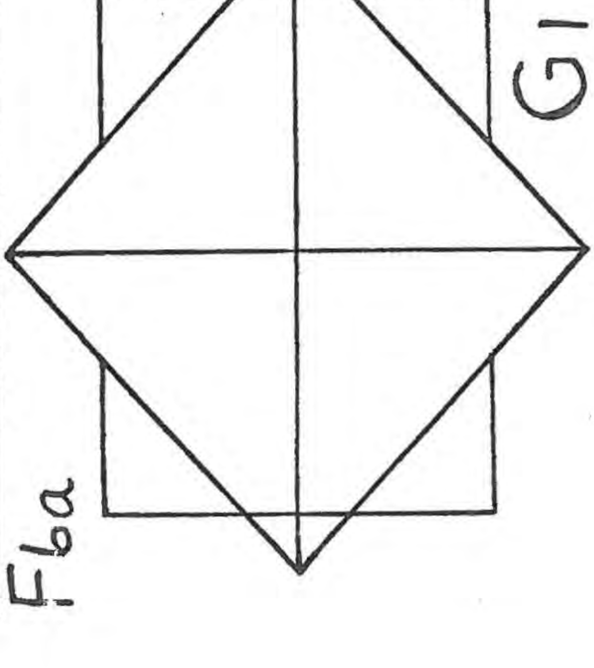

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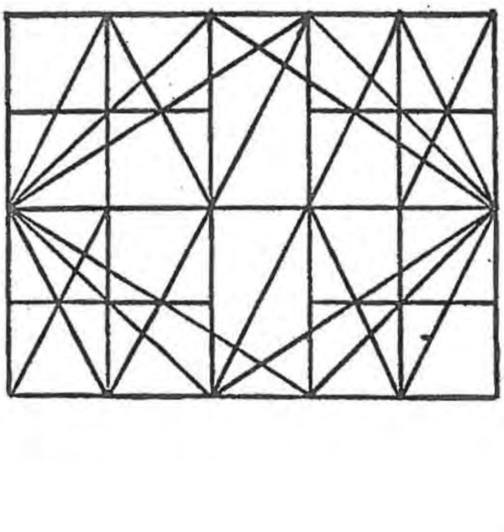

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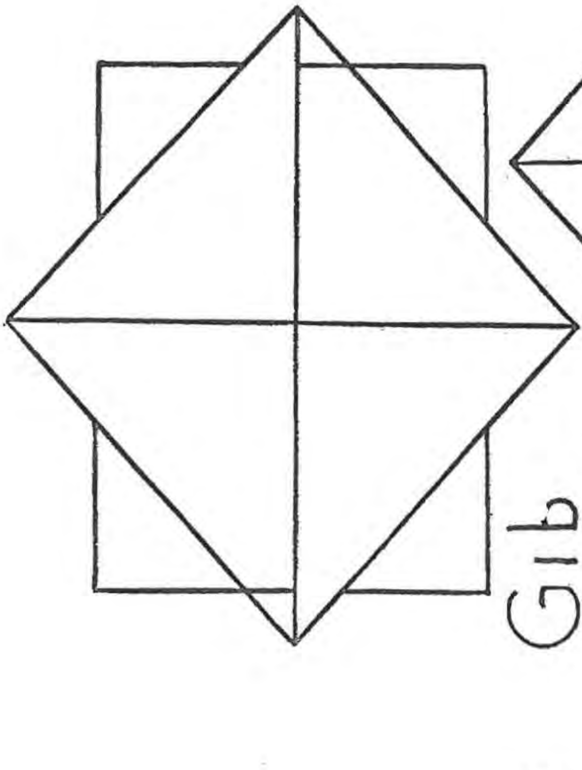

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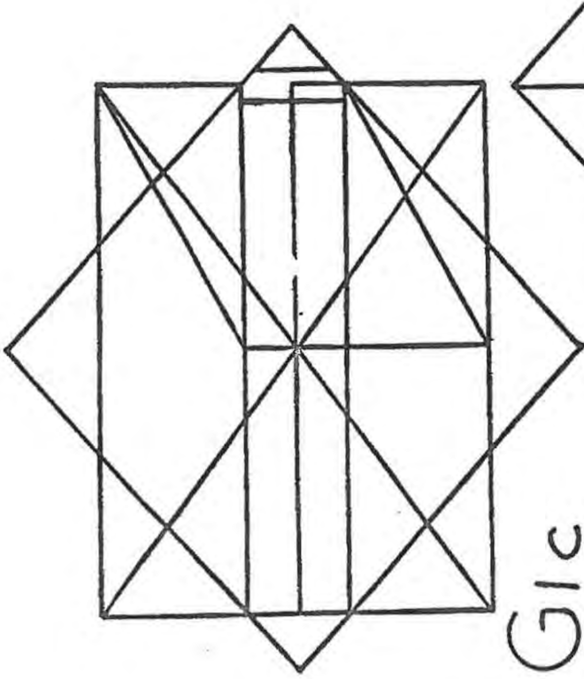

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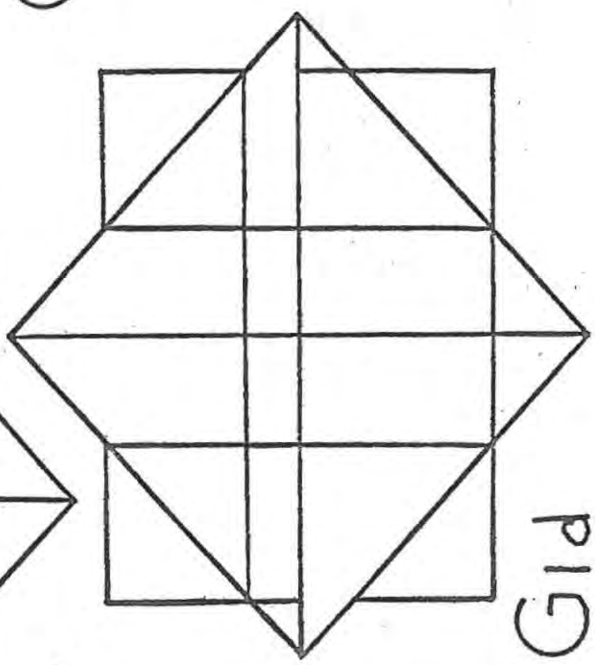

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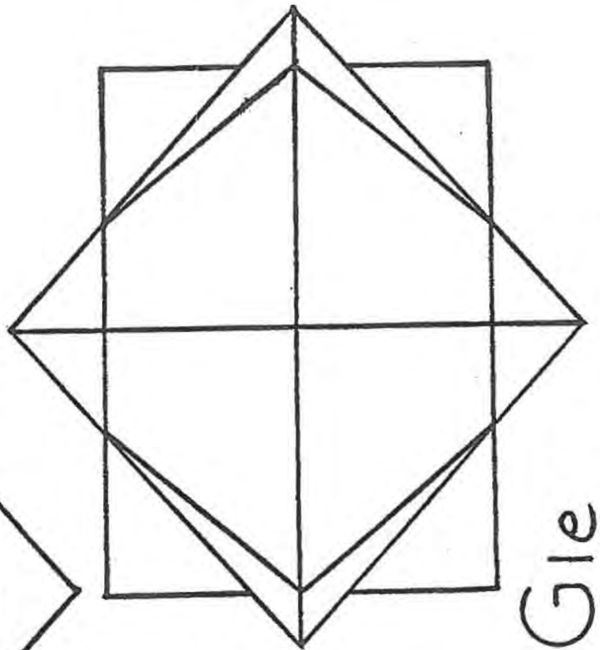

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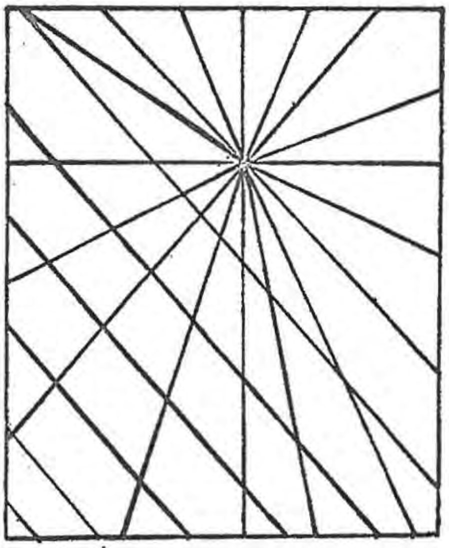

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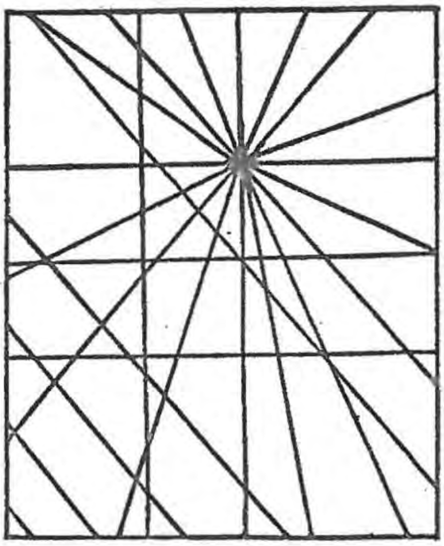

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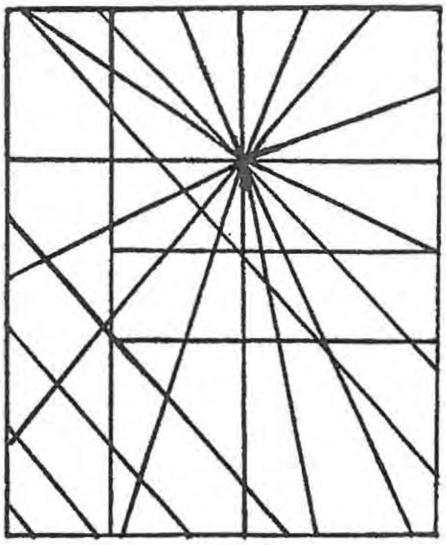

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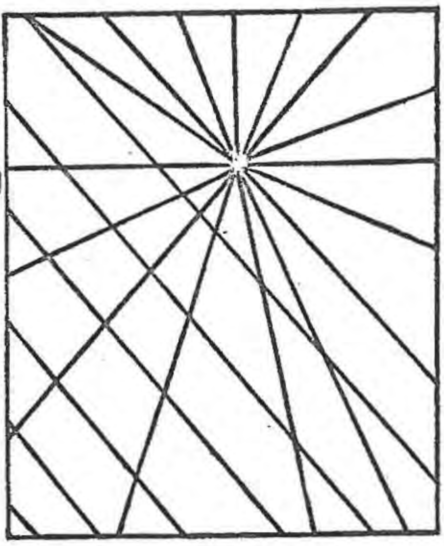

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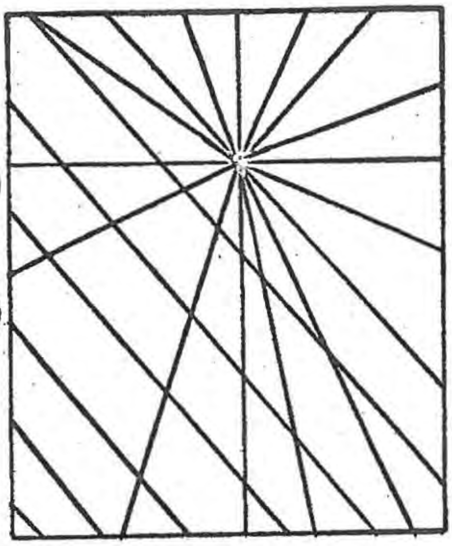

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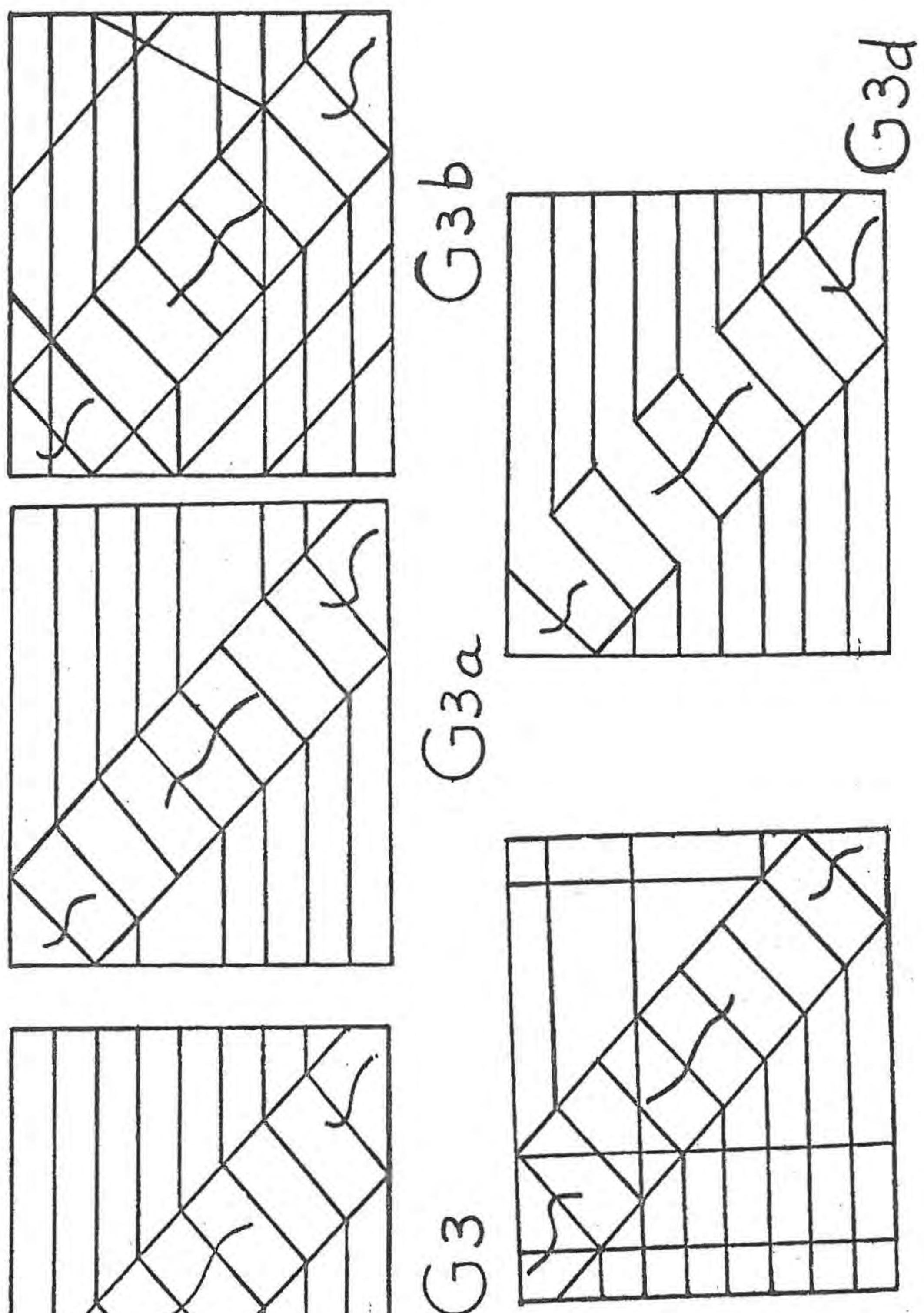
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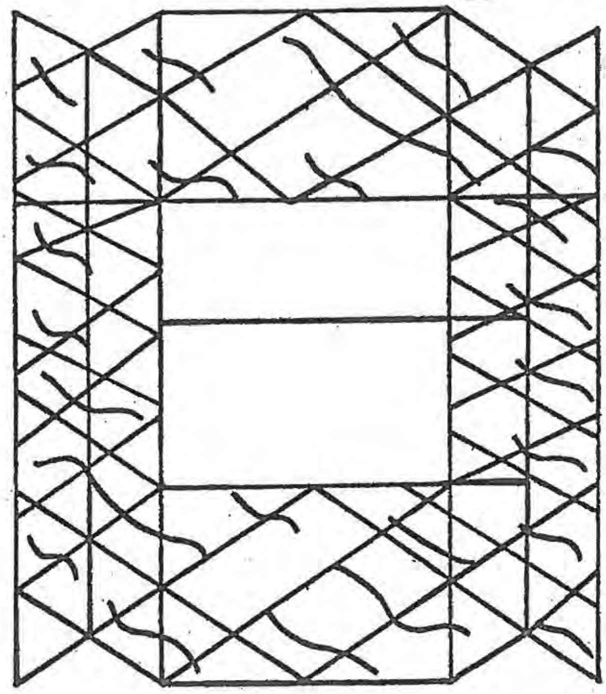

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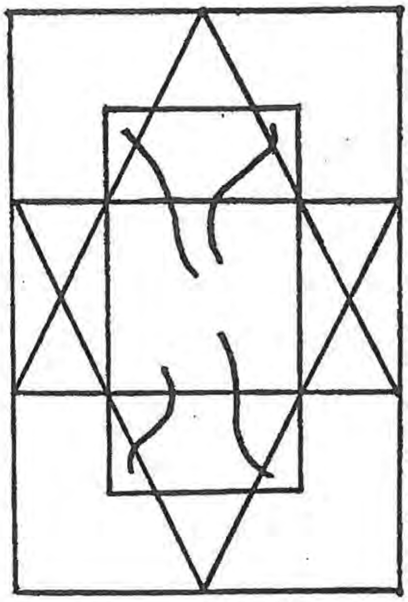

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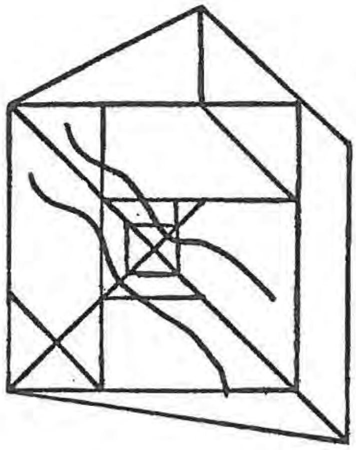

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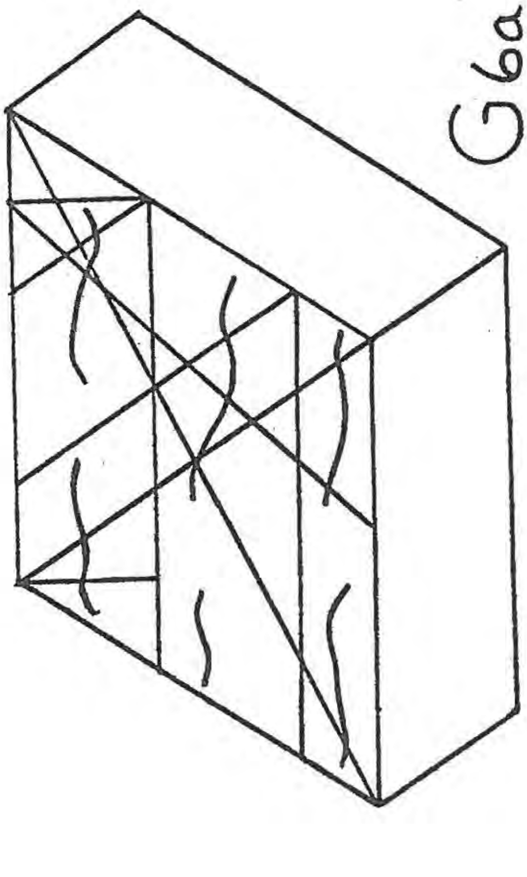

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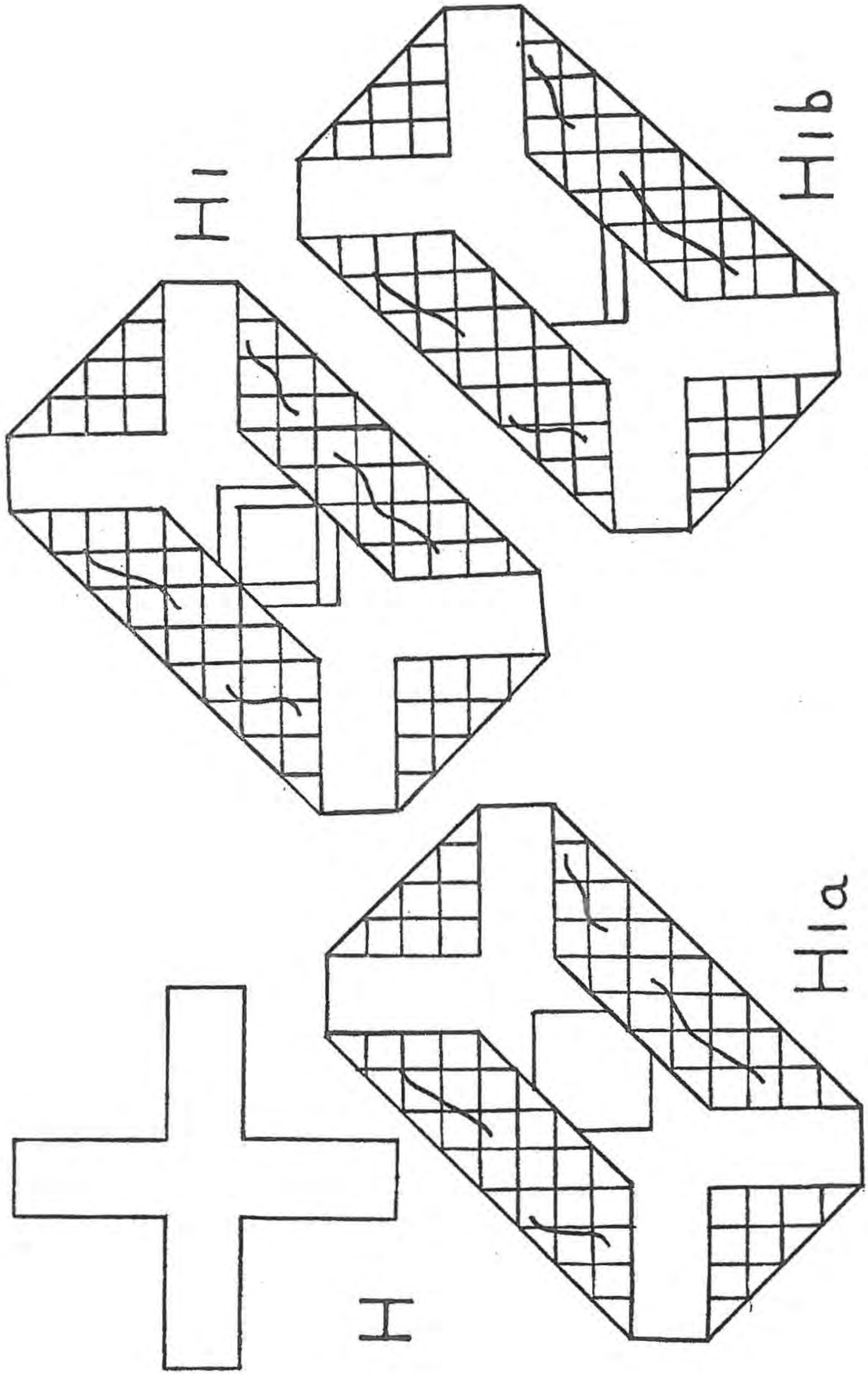
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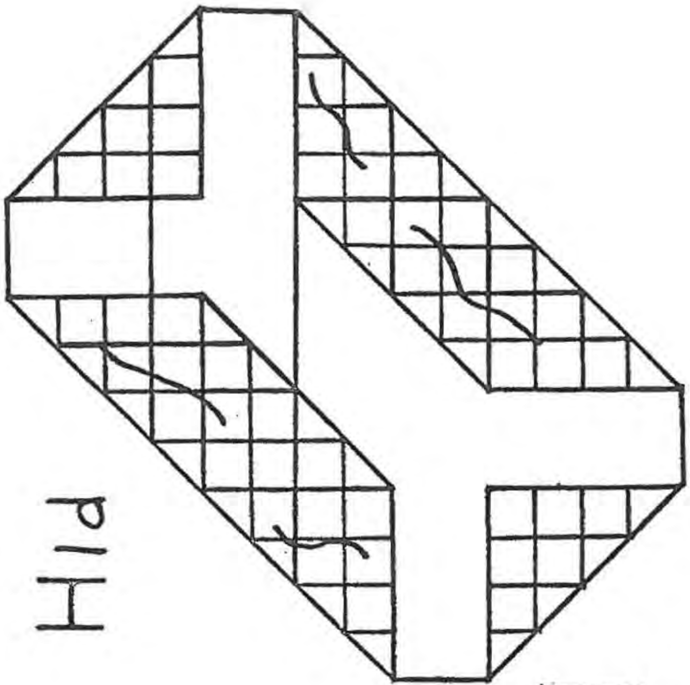

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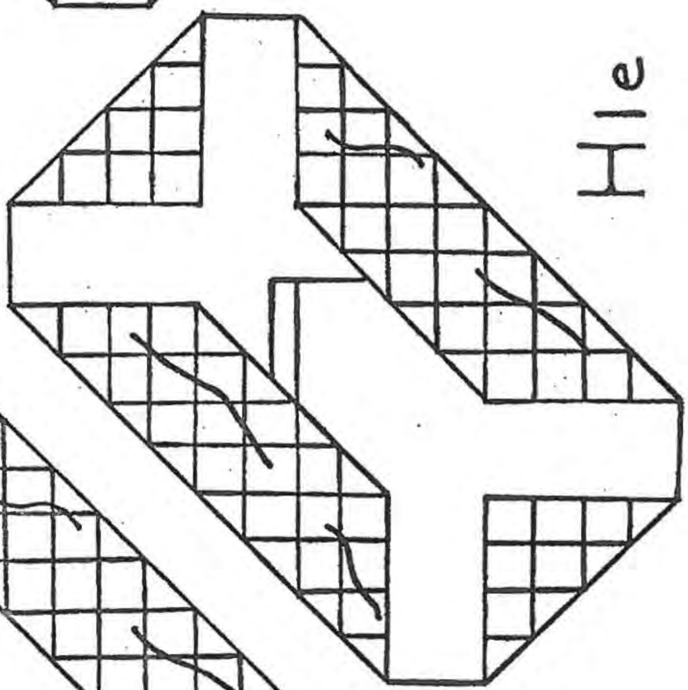

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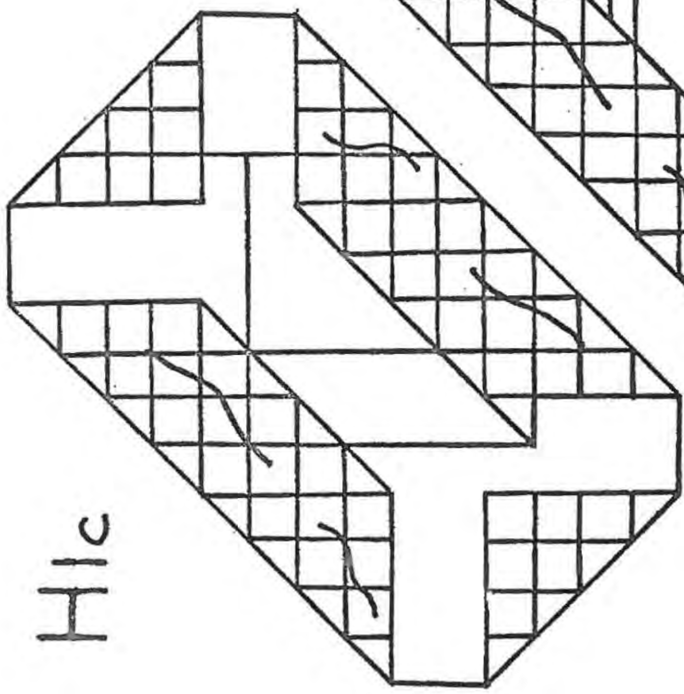

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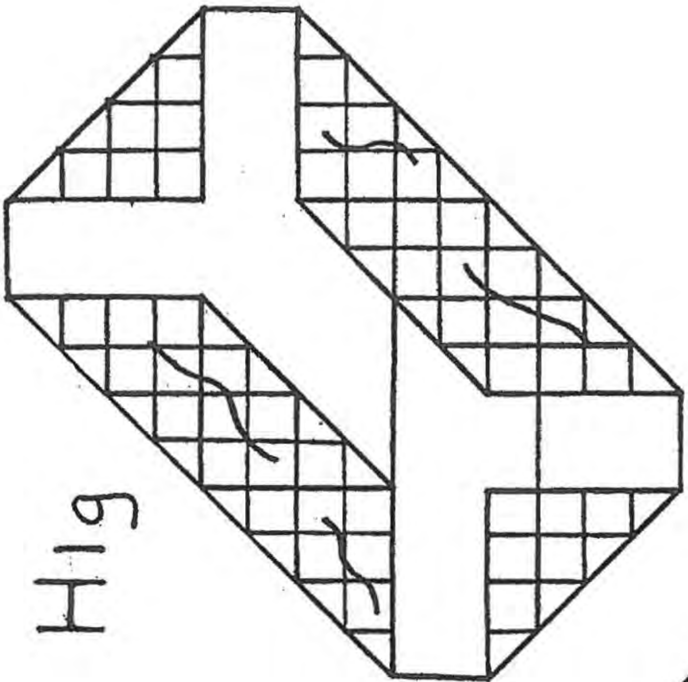

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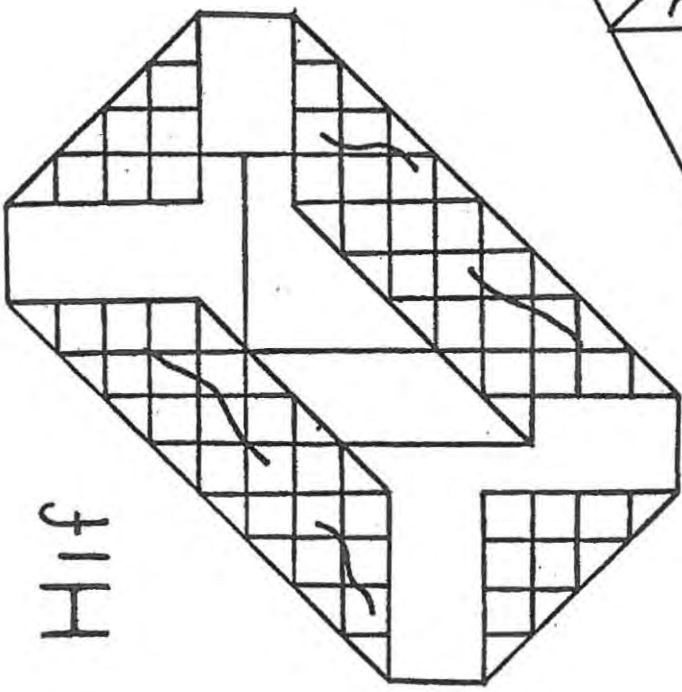

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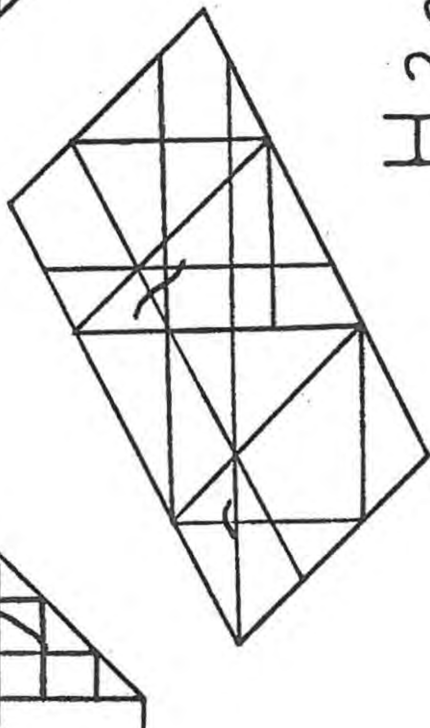

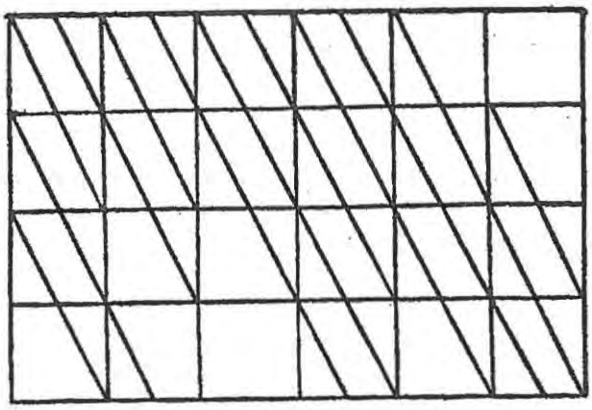

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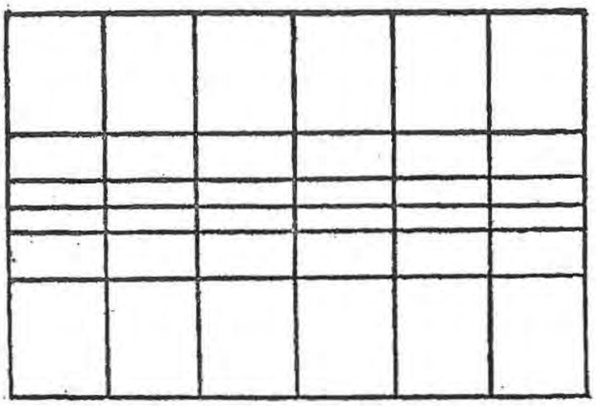

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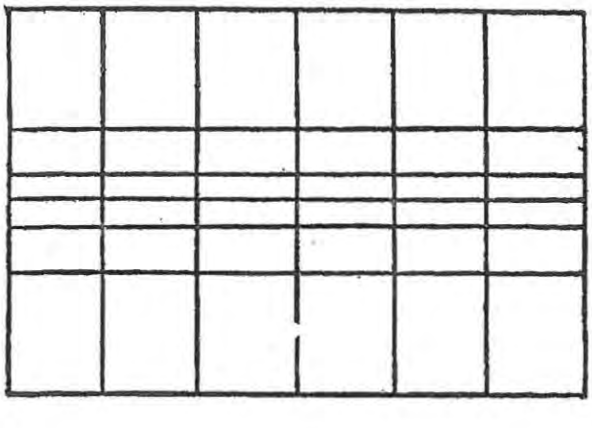

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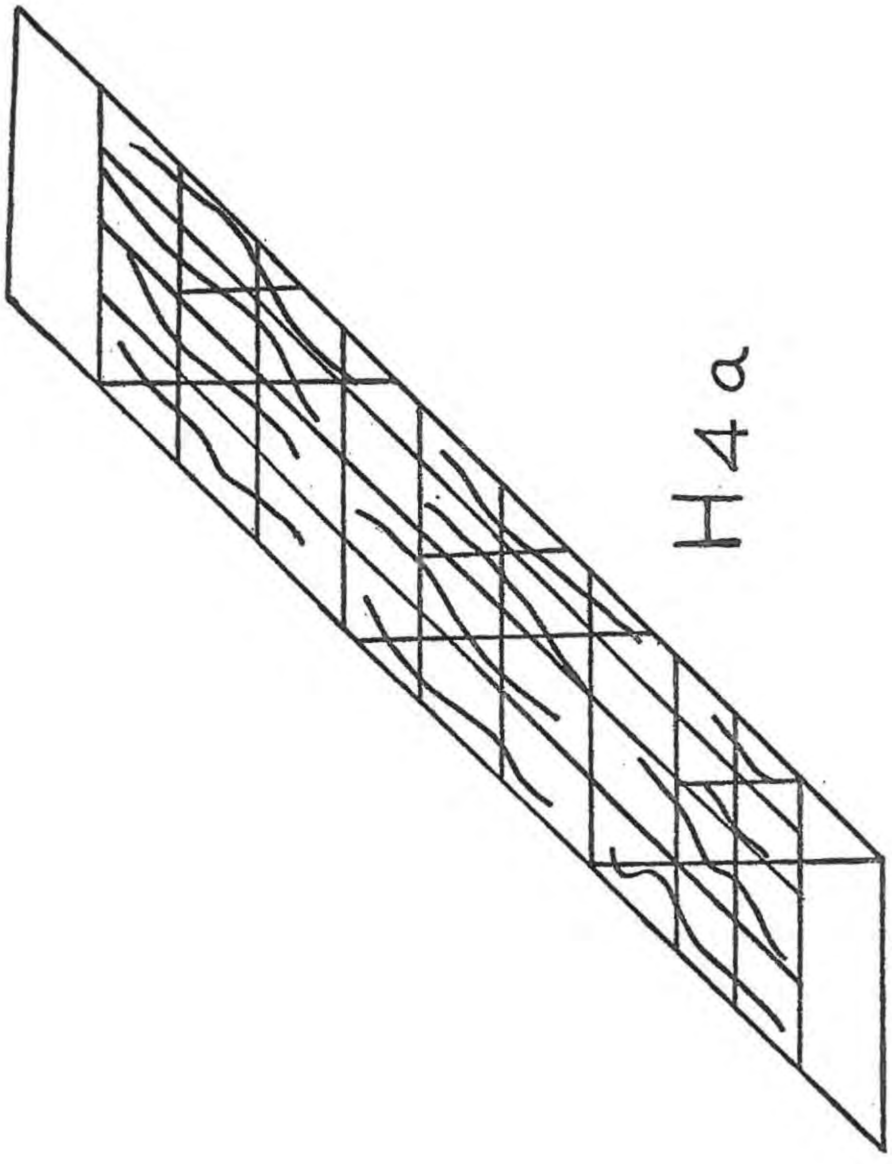

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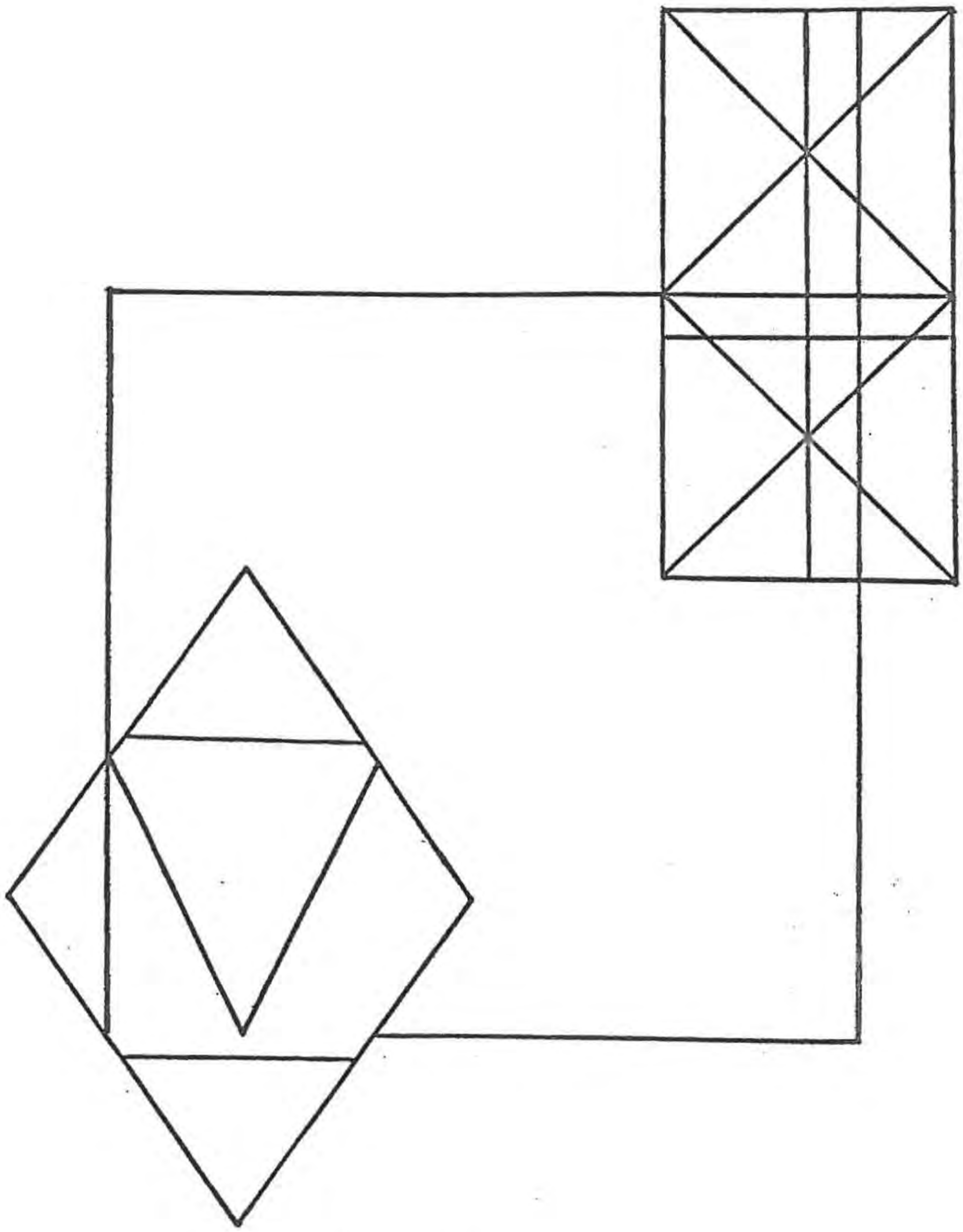

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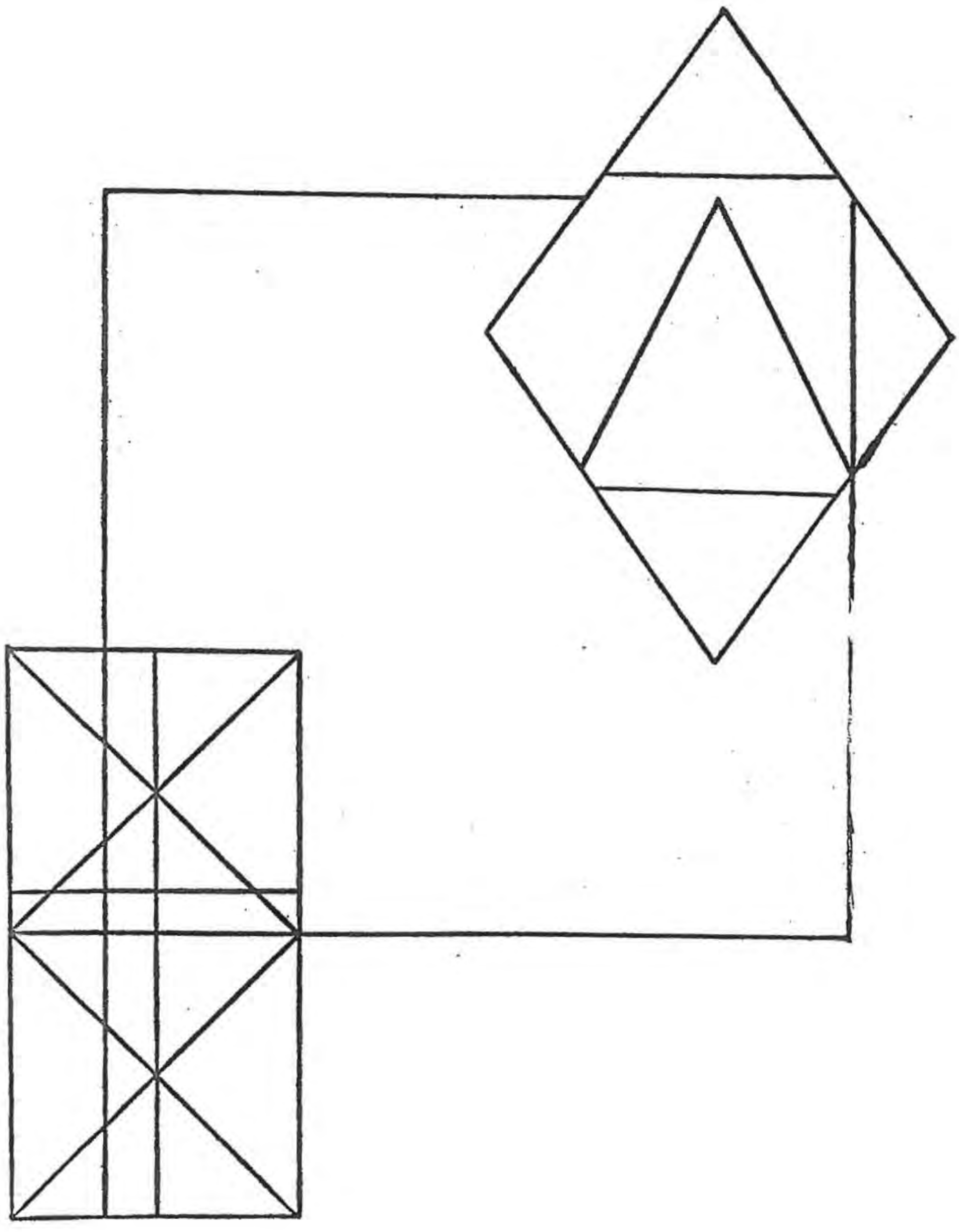

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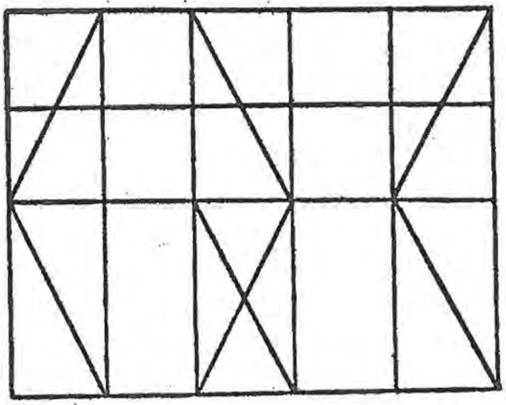

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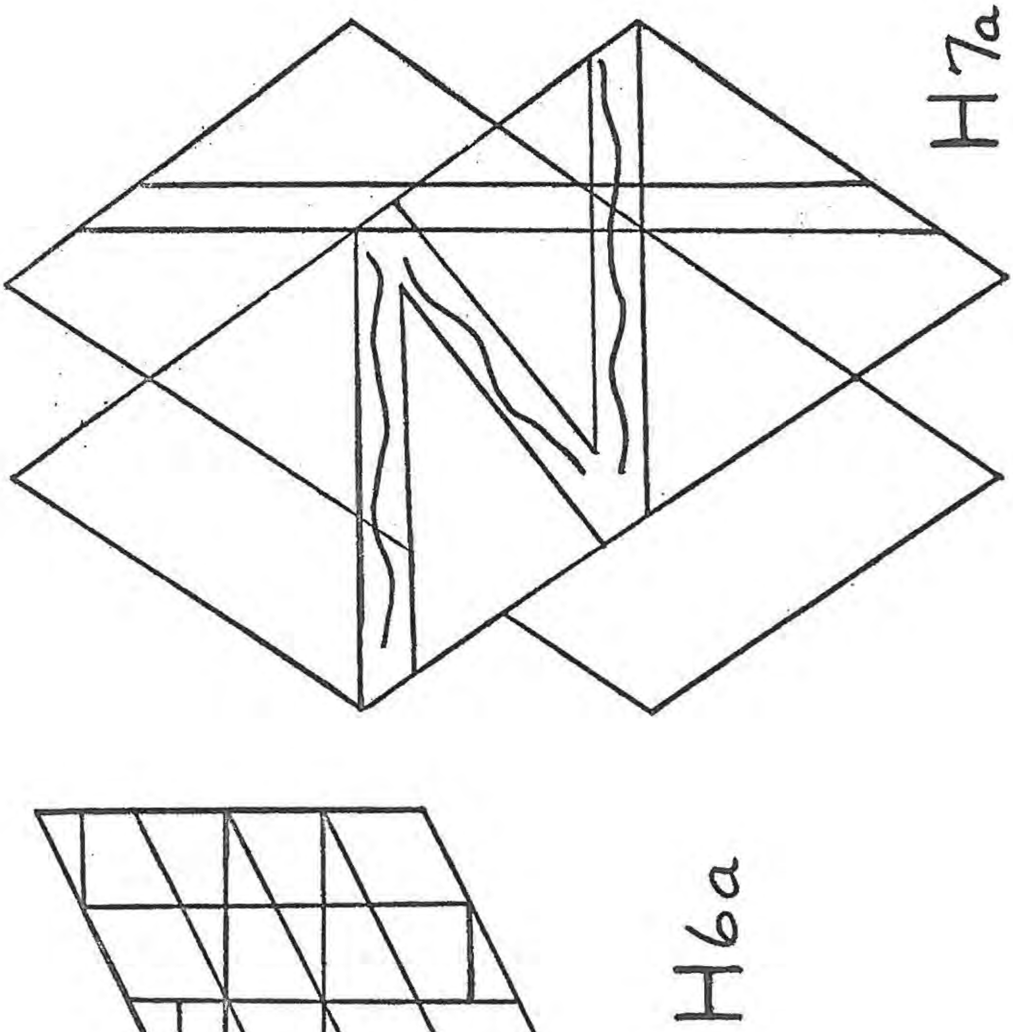

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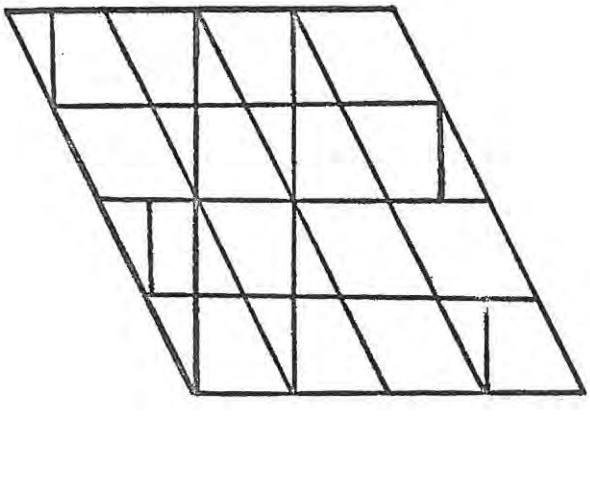

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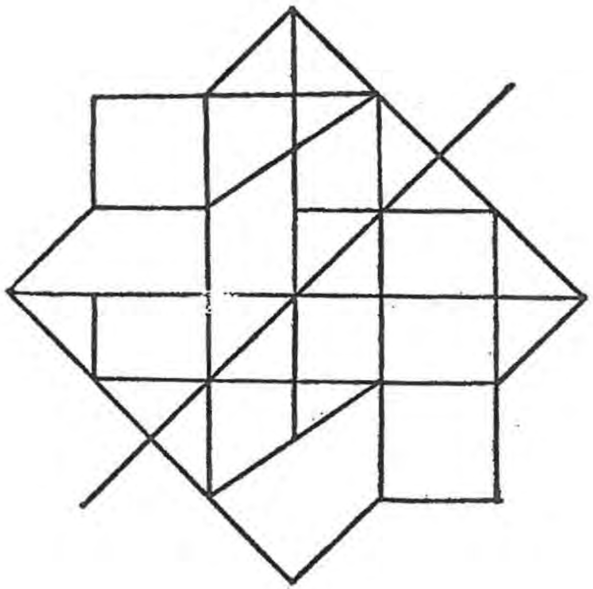

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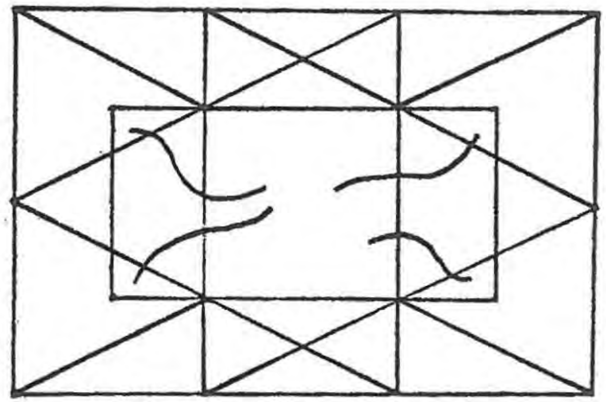

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